TECHNICAL ASPECTS OF NUCLEAR NONPROLIFERATION: SAFEGUARDS

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND PRODUCTION

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

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TECHNICAL ASPECTS OF NUCLEAR NONPROLIFERATION: SAFEGUARDS

TUESDAY, AUGUST 3, 1982

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Research and Production,
Washington, D.C.

The subcommittee met, pursuant to notice, at 1 p.m., in room 2318, Rayburn House Office Building, Hon. Marilyn L. Bouquard (chairman of the subcommittee) presiding.

Present: Representatives Bouquard, Wolpe, Shamansky, Lujan, Lowery, and Hollenbeck.

Mrs. **Bouquard**. The subcommittee will come to order. I want to welcome all you ladies and gentlemen to our hearings today. This is the first of two hearings the Subcommittee on Energy Research and Production will be conducting on safeguards research and development.

Safeguards are a vital element of our overall nuclear nonproliferation policy. Effective safeguards are widely perceived as essential to the health and the vitality of international nuclear cooperation and commerce.

These hearings will examine both domestic and international safeguards. Within this context, it is important to clarify that there are distinct differences between the two. Domestic safeguards have come to mean a system that includes material control and accounting and physical protection for the purpose of preventing theft of materials and sabotage of facilities by individuals or subnational groups. The objective of the International Atomic Energy Agency [IAEA] safeguards, on the other hand, is defined as the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or other nuclear activities or for purposes unknown, and deterrence of such diversion by the risk of early detection.

It is important to recognize that IAEA safeguards are not intended to physically prevent diversion, to identify or apprehend a diverter, to recover diverted materials, to allow for searches for clandestine materials or facilities, nor deal with the known nuclear facilities not under safeguards. This is the purpose of domestic safeguards. Much of the criticism that has been leveled at the IAEA safeguards as being ineffective has been based on a misunderstanding, either real or intentional, as to what constitutes IAEA safeguards. To carp about international safeguards for not accomplishing what they were never intended to accomplish is unfair, unjustified, misinforms the public at large, and undermines confidence in the entire safeguards system.

It is also important to recognize that safeguards do not in themselves constitute the entire proliferation regime. IAEA safeguards are but one element in a complex of international arrangements, diplomatic actions, export controls, and national technical means which, in toto, form the regime. Safeguards do not, nor were they ever meant to, carry the entire weight of nuclear nonproliferation.

We must, however, note that valid concerns have been expressed about nuclear safeguards in general, and the IAEA safeguards in particular. There is, I believe it is fair to say, a consensus that these safeguards need improvement. It is my hope that these hearings will contribute to this constructive process.

Current safeguards R&D programs are carried out by a number of Federal agencies and laboratories. The subcommittee wants to insure that these programs are coordinated and implemented effectively to achieve meaningful nonproliferation goals in a framework of a healthy civilian nuclear option.

Today, the subcommittee will receive testimony from witnesses from the Department of Energy, the Nuclear Regulatory Commission, the Arms Control and Disarmament Agency, and the Department of State.

Welcome, gentlemen. I am looking forward to hearing your testimony. I would also like to welcome the ranking Republican member of this committee, the Honorable Manuel Lujan.

Mr. LUJAN. Thank you, Madam Chairman. I do have an opening statement.

Nuclear proliferation became an issue when the first atomic bomb was exploded and has continued as a national and international concern. Safeguard systems were initially developed for the weapons program but are now applied to the fuel cycle for nuclear power as well.

When the International Atomic Energy Agency was founded, the United States was expected to take a leadership role. Not only was the United States the primary source of safeguards technology and knowhow but the United States provided a major portion of the funding and staff expertise. In addition, the U.S. Ambassadors to the IAEA were expected to fill the leadership role institutionally, such as formulating the agenda for meetings, recommending the constitution of panels, and so on.

Over time that situation has changed. Now the leadership of the United States in the IAEA is resented by some member countries, who feel that it is not leadership but dominance. Even the generous contributions of money, manpower, equipment, and know-how by the United States have resulted in resentment and resistance. The result is that the technical aspects of nonproliferation are intertwined with various institutional and political issues. As the IAEA gains new members, it is likely that those problems will continue.

There has been a lot of renewed activity on nonproliferation issues, with a great deal of rhetoric. With the diplomatic and political problems providing a major challenge, it is important that the United States take a long-term view combined with a sense of urgency.

I believe the United States must give a constant high priority to proliferation concerns and not allow a policy of "out of sight, out of mind." We must continue to develop safeguards technologies and systems. We must work to assure these innovations are effective and adopted by the IAEA and member countries. We must insure the success of the IAEA by sending our best people to share their expertise, and we must work patiently and with constant dedication toward resolving the myriad of political problems involved in an international institution such as the IAEA.

Most of all, we must understand that nuclear nonproliferation cannot be assured overnight. It can only be assured through the attention of high-level policymakers in the administration. This group includes our distinguished witnesses today and those who work over and under them.

Madam Chairman, I join you in welcoming the witnesses this afternoon and I look forward to hearing their views. Thank you very much.

Mrs. BOUQUARD. Thank you very much, Congressman Lujan. We are also happy to have Congressman Shamansky, who is a member of the full committee who has expressed an interest in today's hearing. We welcome you to the hearings today.

Mr. SHAMANSKY. Thank you, Madam Chairman. May I just say a word?

Mrs. BOUQUARD. Please.

Mr. SHAMANSKY. I do appreciate the opportunity of being here at the beginning of this hearing. Last November, as a member of the Foreign Affairs Committee, I stopped at the International Atomic Energy Agency in Vienna for the purpose of reviewing their safeguards program, so my interest has been of long standing. I would just like to note before we proceed that I think your excellent introductory statement illustrates for me part of the problem that certainly I, as an American, think most Americans have—the confusion between the definition of safeguards as the timely detection of the diversion of significant quantities of nuclear material and the fact that the IAEA safeguards are not intended to prevent diversion. I find this a fuzzy area and I do not feel we do the cause of the IAEA, the nuclear industry, or the American public any favors by permitting the confusion to continue. I think there is a confusion by using the word "safeguards" interchangeably when in fact, as you note, they are not the same thing. Perhaps, coming from this, we could make some progress on clearing up that confusion. Thank you for permitting me to make these remarks.

Mrs. BOUQUARD. We thank you very much for your contribution. We hope that our hearings will be not only enlightening but productive as well, and we know they will be with our distinguished panel of witnesses that we have today. Our first witness is Mr. Ralph Caudle, who is Director of the Office of Safeguards and Security with the U.S. Department of Energy. Please proceed with your testimony. Do you have a statement for the record?

Mr. CAUDLE. Madam Chairman, I have two statements, one with a blue cover for the record. I would like to ask your permission to enter that into the record and then present to you this afternoon an abbreviated version that has a pink cover. I have provided copies of those for your subcommittee.

Mrs. **Bouquard**. Please proceed as you wish. Without objection, your entire statement will be made a part of the record.

Mr. **Caudle**. Thank you.

STATEMENT OF RALPH E. CAUDLE, DIRECTOR, OFFICE OF SAFEGUARDS AND SECURITY, U.S. DEPARTMENT OF ENERGY

Mr. **Caudle**. Madam Chairman and members of the committee, it is a pleasure to appear before you to discuss the technical aspects of nuclear nonproliferation, with particular emphasis on safeguards. Prior to specifically discussing with you your questions concerning technical safeguards issues, I would like to briefly talk about the role of the Office of Safeguards and Security in safeguards development. However, since your committee has an interest in nuclear nonproliferation, I will focus on our baseline technology development programs which benefit both the domestic and the international sectors.

We provide direct and indirect technical assistance to the international safeguards regime managed by the International Atomic Energy Agency [IAEA]. We provide direct support by managing the U.S.-funded program of technical assistance to the IAEA, funded by the Department of State in response to urgent and longer term technology needs of the IAEA. In addition, much of the technology which we develop for domestic application is transferred selectively to the IAEA and to international safeguards inspectors through training programs sponsored by the DOE.

Other international safeguards activities include the tracking of nuclear materials and independent physical security reviews of foreign facilities that have received U.S.-origin special nuclear material. Indirect assistance is provided through our participation with the Department of State, the Arms Control and Disarmament Agency, and the Nuclear Regulatory Commission in various technical working groups which provide support to the IAEA. Safeguards experts from several of our national laboratories participate on those working groups and provide the scientist-to-scientist interface which is invaluable in the transfer of safeguards technology.

I would like to address now the specific issues which you stated were of interest to the committee.

Our laboratories have been designing, building, testing, and installing instruments and equipment for the nondestructive assay of uranium and plutonium for about 15 years. This equipment allows inspectors to quickly and accurately measure uranium and plutonium in nuclear facilities without the need to remove samples. Typically, portable, easy-to-operate equipment is required for IAEA field inspections, whereas larger, more sophisticated in-plant equipment has been supplied for domestic use.

Portable nondestructive assay equipment provided to the IAEA in the past 5 years by the United States under the program of technical assistance to IAEA safeguards has, in general, been of high quality, reliable, and easy to operate. The major factors faced by the IAEA in getting the full use of this equipment have been the development of measurement procedures for the wide varieties of nuclear materials.

I would like to now discuss containment and surveillance technology. This technology has been developed primarily for international application, although it, like much international technology, finds its roots in our domestic safeguards program. Its utility in international safeguards arises from its capability to augment and to a certain extent relieve the requirement for on-location presence of inspectors and for routine and repetitive inspections at facilities such as nuclear power reactors or storage facilities where nuclear materials inventories may be relatively static.

In the area of containment, our support program has also provided equipment and technology such as fibre optic and new metallic seals which can be used to verify that rooms, vaults, or containers have not been tampered with.

The scope of DOE's domestic safeguards program relates to all of its nuclear materials and facilities, as well as to new power reactor concepts and related fuel cycle facilities. The general objective is to prevent successful malevolent acts involving nuclear materials and facilities. Tools of the integrated safeguards system include physical protection, material control, material accountability activities to prevent theft, diversion, or sabotage of nuclear weapons, special nuclear materials, or vital equipment. In addition, DOE's U.S. national security responsibilities include technical support to nuclear nonproliferation objectives and international safeguards. In fulfilling these responsibilities and commitments, the Office of Safeguards and Security [OSS] sponsors research, development, tests, and evaluations to improve safeguards effectiveness and correct specific deficiencies related to weapons development and production, nuclear materials production facilities, and nuclear energy development programs. The same safeguards and security technology base with adaptations, modifications, and spinoff provide substantial contributions to international safeguards. The research and development is carried out primarily by the Department's national laboratories (Los Alamos, Sandia, Lawrence Livermore, and Oak Ridge are examples) and other DOE contractors having expertise in the areas of concern. Areas of concern are based on specific needs identified by field offices and facility operating contractors, the results of vulnerability studies and assessments, recognized shortfalls in existing equipment, and requested support to the Nuclear Regulatory Commission, its licensees, and the international community. A large portion of the total safeguards and security effort is directed to assisting field offices and facility operators in engineering design, development, procurement, installation, prototype testing, and operational evaluation of systems for specific DOE sites.

The fiscal year 1982 OSS budget for domestic safeguards research and development and field assistance totals $22.5 million. The major elements of this program are approximately $10.4 million in physical protection and $8.2 million in material control and accountability. Not included in these amounts is $6 million funding for nonproliferation initiatives and support to international safeguards. This expenditure is focused on implementation of IAEA safeguards in the United States under the U.S./IAEA agreement. In addition, approximately $4.1 million of State Department funds are used for direct IAEA support through the technical assistance program I mentioned earlier.

Overall coordination with other U.S. departments concerned with nonproliferation and safeguards is provided by regularly scheduled meetings of the Interagency Steering Group [ISG] for safeguards and subsidiary groups such as the action plan working group [APWG] and Technical Support Coordinating Committee [TSCC] which have representatives from the Arms Control and Disarmament Agency, Department of State, U.S. Nuclear Regulatory Commission, as well as my office in the Department of Energy.

Regarding international safeguards cooperation, the greatest single area is our work with the International Atomic Energy Agency [IAEA]. The DOE's Office of Safeguards and Security has established at Brookhaven National Laboratory [BNL] an International Safeguards Project Office [ISPO] which receives, evaluates, and funds—if approved—specific R&D requests for instrumentation, equipment, and procedures. Daily coordination is assured by an International Safeguards Project Office staff member who is assigned as a resident representative at the IAEA.

In addition to coordination with the IAEA, we also work with EURATOM, the nuclear arm of the European Community. This coordination is effected through frequent visits by staff members and by in-residence exchanges of EURATOM and U.S. laboratory scientific staff members. We also cooperate on a bilateral basis with certain nations such as Canada, the United Kingdom, West Germany, and Japan.

We believe that the Department of Energy's Office of Safeguards and Security now has an active and effective safeguards R&D and implementation program with other appropriate nuclear nations and international organizations. However, this technology implementation program is not without some difficulties. I am sure that the committee members can appreciate some of the sensitivities which can arise when we are dealing with a complex mix of technical and institutional concerns in an international arena. None of these concerns has stopped us and our colleagues in other agencies from transferring the technical means which helps the IAEA perform its safeguards mission, but these concerns must be dealt with and are part of the cost of doing business.

The implementation of advanced, as opposed to basic, safeguards technology can be hampered by a lack of awareness on the part of our intended customers within the IAEA and in foreign nations' nuclear safeguards programs as to just what technology is available to them. In addition to the possible lack of awareness of the availability of technology, there is a natural tendency on the part of operating facility managers to not want to disrupt normal operations through the addition of safeguards equipment. However, complex safeguards systems have been successfully installed and tested, once the cooperation of the host nation's government has been secured.

Another concern which arises periodically is the setting of priorities for technology implementation. Within the Department of Energy, we can and do work directly with the program managers to establish priorities on technology implementation in the field. Priorities are established in accordance with the risk to national security which might be posed by malevolent acts against one of our facilities. On the international scene, however, we are institutionally separated from the technology users. We must, therefore, to a great extent depend upon inputs from the IAEA staff and reflect their priorities in the development and transfer of safeguards technology.

In addition to these institutional concerns, there are purely technical concerns which are addressed by our laboratories. All in all, we have not found any of these problems to be insurmountable. They do, however, take time and effort to resolve.

Long-range plans include greater emphasis on components and systems to solve deficiencies identified by comprehensive evaluations and to provide protection against insiders and outsider threats of theft or sabotage at DOE facilities. Equipment to identify contraband (e.g., explosives which could be used for sabotage) will be designed, fabricated, and evaluated in operational environments of one or more DOE facilities. A broadened base of capability for measuring uranium and plutonium materials of different compositions and forms characteristic of advanced nuclear fuel cycles (e.g., the advanced isotope separations breeder fuel cycle) will be pursued to reflect the increasing need and benefits of automated, remote measurements in safeguarding nuclear materials.

I have discussed quite a list of safeguards programs and issues. I would like to conclude by stating that we are doing what we can to provide effective safeguards on our own nuclear materials while supporting a credible international safeguards regime. We are doing this through our baseline technology development programs which benefit both the domestic and international sectors. We are coordinating with other agencies, both international and within the Government, to establish appropriate priorities and avoid duplication of effort. Finally, we are working to resolve issues which could hamper effective safeguards both at home and abroad. I do not claim that these systems are perfect, only that they are credible and we are working to make them better. I would be pleased to entertain any questions you may have at this time, Madam Chairman.

[The prepared statement of Mr. Caudle follows:]

STATEMENT OF

RALPH E. CAUDLE

DIRECTOR, OFFICE OF SAFEGUARDS AND SECURITY
OFFICE OF DEFENSE PROGRAMS
U.S. DEPARTMENT OF ENERGY

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
U.S. HOUSE OF REPRESENTATIVES

AUGUST 3, 1982

TECHNICAL ASPECTS OF NUCLEAR NON-PROLIFERATION: SAFEGUARDS

Madame Chairman and members of the committee, it is a pleasure to appear before you to discuss the "Technical Aspects of Nuclear Non-Proliferation: Safeguards". Prior to specifically discussing with you your questions concerning technical safeguards issues, I would like to briefly talk about the role of the Office of Safeguards and Security (OSS) in safeguards development. However, since your committee has an interest in nuclear non-proliferation, I will focus on our baseline technology development programs which benefit both the domestic and international sectors.

We provide direct and indirect technical assistance to the international safeguards regime managed by the International Atomic Energy Agency (IAEA). We provide direct support by managing the U.S.-funded Program of Technical Assistance to the IAEA funded by the Department of State in response to urgent and longer-term technology needs of that Agency. In addition, much of the technology which we develop for domestic application is transferred selectively to the IAEA and to international safeguards inspectors through training programs sponsored by the DOE. Direct support is also provided through the tracking of nuclear materials and independent physical security reviews of foreign facilities that have received U.S.-origin special nuclear material. Indirect assistance is provided through our participation with the Department of State, the Arms Control and Disarmament Agency, and the Nuclear Regulatory Commission in various technical working groups which provide support to the IAEA. Safeguards experts from several of our national laboratories participate on these working groups and provide the scientist-to-scientist interface which is invaluable in the transfer of safeguards technology.

I would like to address now the specific issues which you stated were of interest to the Committee.

Non-Destructive Assay and Containment and Surveillance

Our laboratories have been designing, building, fabricating, testing and installing instruments and equipment for the non-destructive assay of uranium and plutonium for about fifteen years. Typically, portable, easy-to-operate equipment is required for IAEA field inspections, whereas larger, more sophisticated in-plant equipment has been supplied for domestic use. For controlled measurement situations, such as fuel rods with well-defined geometries and material densities, non-destructive assay equipment can make assays to within 1 percent. For less well-defined situations, such as scrap and waste materials where container geometries and material densities are variable, measurement quality is less precise but often still adequate for effective materials accounting. In addition, measurement of such materials by non-destructive assay may be faster and as accurate as conventional destructive analyses.

Portable non-destructive assay equipment provided to the IAEA in the past five years by the United States under the program of Technical Assistance to IAEA Safeguards has, in general, been of high quality, reliable, and easy to operate. The major factors faced by the IAEA in getting the full use of this equipment have been the development of measurement procedures for the wide varieties of nuclear materials -- sizes, geometries, densities, compositions -- that are found worldwide; the availability of representative physical standards for calibration of the equipment; and the need for more thorough training of IAEA inspectors in the proper use of the equipment.

Now, I would like to discuss containment and surveillance technology. This technology has been developed primarily for international application, although it, like much international technology, finds its roots in our domestic safeguards program. Its utility in international safeguards arises from its capability to augment and to a certain extent relieve the requirement for on-location presence of inspectors and for routine and repetitive inspections at facilities such as nuclear power reactors or storage facilities where nuclear material inventories may be relatively static.

To date, in fact, most attention in this area has been paid to the use of surveillance equipment to maintain continuity of knowledge of spent fuel in storage pools at power reactors. We feel it is certain that additional important applications of surveillance equipment will develop; however, it appears that techniques currently employed will accommodate existing requirements.

Typical surveillance technology now in place includes 8-mm film cameras with large reels, mounted in tamper-indicating enclosures sealed by IAEA inspectors. The cameras take still photographs at pre-set intervals. Film is developed and reviewed by IAEA staff to insure that no abnormal activities have occurred since the last visit by IAEA inspectors. TV camera systems which operate over a much wider range of environmental conditions and have a capacity to store much more data have been developed and are in routine use by the IAEA. More advanced TV systems are under test and evaluation for use to supplement or replace the still cameras. We are working on more compact, advanced TV camera systems in close coordination with IAEA technical staff regarding operational and performance requirements for the system.

In the area of containment, our support program has also provided equipment and technology such as fibre optic and new metallic seals which can be used to verify that rooms, vaults or containers have not been broken into.

Scope, Mission Effectiveness, and Cost of Safeguards R&D Programs

The scope of DOE's domestic safeguards program relates to all of its nuclear materials and facilities, as well as to new power reactor concepts and related fuel cycle facilities. The general objective is to prevent successful malevolent acts involving nuclear materials and facilities. Tools of the integrated safeguards system include physical protection, material control, and material accountability activities to prevent theft, diversion, or sabotage of nuclear weapons, special nuclear materials, or vital equipment. In addition, DOE's U.S. national security responsibilities include technical support to nuclear non-proliferation objectives and international safeguards. In fulfilling these responsibilities and commitments, the Office of Safeguards and Security (OSS) sponsors research, development, tests and evaluations to improve safeguards effectiveness and correct specific deficiencies related to weapons development and production, nuclear materials production facilities, and nuclear energy development programs. The same safeguards and security technology base with adaptations, modifications, and spinoff provides substantial contributions to international safeguards.

The DOE/OSS-sponsored domestic R&D program is directed to designing, developing, demonstrating, assisting in implementation of (1) a strong physical protection subsystem of access and egress controls, barriers and intrusion detection alarm equipment to provide multiple obstacles between the material or vital equipment and a would-be thief or saboteur; (2) a reliable and rapid materials control subsystem to govern internal movement of material and monitor the status of process flows and inventories; and (3) an accurate and timely materials accountability subsystem to determine quantities of material in receipts, shipments and inventories, maintain records and perform data analysis and evaluation.

The R&D is carried out primarily by the Department's national laboratories (Los Alamos, Sandia, Lawrence Livermore, Oak Ridge) and other DOE contractors having expertise in the areas of concern. Areas of concern are based on specific needs identified by field offices and facility operating contractors, results of vulnerability studies and assessments, recognized shortfalls in existing equipment, and requested support to NRC, its licensees and the international community. A large portion of the total safeguards and security effort is directed to assisting field offices and facility operators in engineering design, development, procurement, installation, prototype testing, and operational evaluation of systems for specific DOE sites.

The effectiveness of the R&D programs can be measured in part by the acceptance of developed instruments and systems. The laboratories receive many requests for consultation in system design, prototype instruments and designs. In addition and as part of the technical assistance program, a comprehensive system evaluation capability is provided in direct support to improvement projects. Results are analyzed and integrated into a cohesive base to identify cost-effective and optimized designs to meet site-specific threats. This approach has been tested and is currently being successfully applied to several DOE sites.

The FY 1982 OSS budget for safeguards R&D and field assistance totals $22.5 M. The major elements of this program are approximately $10.4 M in physical protection and $8.2 M in materials control and accountability. Included in these amounts is $6.0 M funding for non-proliferation initiatives and support to international safeguards. This expenditure is focused on implementation of IAEA safeguards in the U.S. under the U.S./IAEA Agreement. The largest single effort is the development of safeguards concepts for application at the planned Gaseous Centrifuge Enrichment Plant at Portsmouth, Ohio.

International Safeguards Coordination

Coordination with other U.S. Departments and Agencies regarding these activities is on a continuing basis. For example, the DOE's New Brunswick Laboratory works closely with domestic and international users in providing analytical material standards (uranium and plutonium), as well as in developing chemical analytical methods.

Overall coordination with other U.S. Departments concerned with non-proliferation and safeguards is provided by regularly scheduled meetings of the Interagency Steering Group (ISG) for safeguards and subsidiary groups such as the Action Plan Working Group (APWG) and Technical Support Coordinating Committee (TSCC) which have representatives from the Arms Control and Disarmament Agency, Department of State, U.S. Nuclear Regulatory Commission, as well as my office in the Department of Energy.

Regarding international safeguards cooperation, the greatest single area is our work with the International Atomic Energy Agency (IAEA). The DOE's Office of Safeguards and Security has established at Brookhaven National Laboratory (BNL) an International Safeguards Project Office (ISPO) which receives, evaluates, and funds (if approved) specific R&D requests for instrumentation, equipment, and procedures. Daily coordination is assured by an ISPO staff member who is assigned as a resident representative at the IAEA.

In addition to coordination with the IAEA, we also work with EURATOM, the nuclear arm of the European Community. This coordination is effected through frequent visits by staff members, and by in-residence exchanges of EURATOM and U.S. laboratory scientific staff members.

Finally, we also cooperate on a bilateral basis with certain nations. Under existing U.S. bilateral agreements, we pursue joint R&D projects with nations such as Canada, the United Kingdom, West Germany and Japan.

We believe DOE/OSS now has an active and effective safeguards R&D and implementation program with other appropriate nuclear nations and international organizations.

Technology Implementation Problems

However, this technology implementation program is not without some difficulties. I am sure that the Committee members can appreciate some of the sensitivities which can arise when we are dealing with a complex mix of technical and institutional concerns in an international arena. None of these concerns has stopped us and our colleagues in other agencies from transferring the technical wherewithal which helps the IAEA perform its safeguards mission. But these concerns must be dealt with and are part of the costs of doing business. Let me be specific.

The implementation of advanced as opposed to basic safeguards technology can be hampered by a lack of awareness on the part of our intended customers within the IAEA and in foreign nations' nuclear safeguards programs as to just what technology is available to them. This concern is addressed through technical symposia, such as the just-completed annual meeting here in Washington of the Institute of Nuclear Materials Management and the meeting of the European Safeguards Research and Development Association (ESARDA) in The Netherlands. We also provide annual training programs specifically geared to the international audience at Sandia and Los Alamos National Laboratories. These are in addition to our extensive and continuing contacts through the Technical Steering Coordinating Committee which establishes priorities for technical assistance through the Program of Technical Assistance to the IAEA.

In addition to the possible lack of awareness of the availability of technology, there is a natural tendency on the part of operating facility managers to not want to disrupt normal operations through the addition of safeguards equipment. This can hinder the in-situ testing of safeguards systems if extensive installation efforts are required. However, complex safeguards systems have been successfully installed and tested once the cooperation of the host nation's government has been secured. Such cooperation is usually forthcoming when it is appreciated that some safeguards technology (surveillance cameras, for example) can reduce the frequency or extent of IAEA inspections and that, in general, the overall effectiveness of international safeguards is enhanced when newer, more effective technology can be installed.

Another concern which arises periodically is the setting of priorities for technology/implementation. Within the Department of Energy, we can and do work directly with program managers to establish priorities on technology implementation in the field. Priorities are established in accordance with the risks to national security which might be posed by malevolent acts against one of our facilities. On the international scene, however, we are institutionally separated from the technology users. We must, therefore, to a great extent, depend upon inputs from the IAEA staff and reflect their priorities in the development and transfer of safeguards technology. To date, IAEA priorities have tended to focus on the development of safeguards technology for application to bulk processing facilities and nuclear reactors. Their priorities have focused on two concerns. One is the continuing need for confident and continuous verification of nuclear materials on hand at each facility. The other is the need to make the most efficient use of a limited number of safeguards inspectors.

In addition to these institutional concerns, there are purely technical concerns which are addressed by our laboratories. These concerns include the need for complete documentation for available equipment, post-sale servicing of equipment by vendors, and the limited availability of specialized equipment. It also should be kept in mind that we are dealing with a very wide variety of nuclear materials in terms of the chemical and physical forms which must be measured and controlled. Hence, the technical issue of diversity of application is always present and must be dealt with. As a specific example, very different instrument geometries must be employed in the measurement of plutonium metal "buttons" as compared with a sample of plutonium nitrate liquid solution. On balance, the diversity of nuclear materials under safeguards worldwide does not pose insurmountable problems by any means. But it does require additional attention to the end use when instrumentation and other equipment is developed.

Long-Range Plans for Improving Equipment and Techniques

Long-range plans include greater emphasis on components and systems to solve deficiencies identified by comprehensive evaluations and to provide protection against insider and outsider threats of theft or sabotage at DOE facilities. Equipment to identify contraband (e.g., explosives) will be designed, fabricated and evaluated in operational environments of one or more DOE facilities. A broadened base of capability for measuring uranium and plutonium materials of different compositions and forms characteristic of advanced nuclear fuel cycles (e.g., Advanced Isotope Separations, breeder fuel) will be pursued to reflect the increasing need and benefits of automated, remote measurements in safeguarding nuclear materials.

An example of the type of long-range improvement is our assistance to the DOE field in the conceptual design and procurement of a central alarm and monitoring station for protective guard force response at a major production complex servicing several widely separated facilities at a DOE site.

Additional future improvements also include the need for preparation of an adequate and sufficient material standards reference base for calibrating non-destructive assay and chemical measurements across the fuel cycle. This includes expansion of safeguards-related measurement comparison programs and evaluation of proven non-destructive measurement technology.

Past support under the international program has included studies, preliminary concepts and vulnerability analysis, identification of safeguards options, and feasibility of applying advanced materials accountancy and containment and surveillance (C/S) technology. We have developed concepts for international safeguards for reprocessing plants. This involves support of efforts of the International Working Group Reprocessing Plant Safeguards. In addition, we have developed measurement and C/S devices to support safeguards options for a variety of fuel cycle facilities as examples of this support. Planned future needs include assistance to C/S programs for application of IAEA safeguards under the U.S./IAEA Agreement at DOE facilities selected for IAEA safeguards and to support commitments under the Nuclear Non-Proliferation Act of 1978. Efforts will be directed to assure that application can be accomplished in a realistic, effective and practical manner while protecting sensitive national security information and restricted data. This information includes the physical security and materials control and accountability plan for systems designs, the U.S. Gas Centrifuge Enrichment Plant, concepts for Advanced Isotope Separation, and for breeder fuel, storage and reprocessing. Specialized techniques and equipment will be reviewed to monitor process material flows, transfers, and inventories within bulk fabrication and processing facilities, including unique methods for identifying the composition and verification of fuel elements held in storage and transfer.

Conclusion and Summary

I have discussed quite a list of safeguards programs and issues. I would like to conclude by stating that we are doing what we can to provide effective safeguards on our own nuclear materials while supporting a credible international safeguards regime. We are doing this through our baseline technology development programs which benefit both domestic and international sectors. We are coordinating with other agencies, both international and within the Government, to establish appropriate priorities and avoid duplication of effort. Finally, we are working to resolve issues which could hamper effective safeguards both at home and abroad. I don't claim that these systems are perfect, only that they are credible and we are working to make them better.

I would be pleased to entertain any questions you may have at this time.

Mrs. BOUQUARD. Thank you very much, Mr. Caudle, for your fine testimony. Mr. John Davis from the Nuclear Regulatory Commission is our next witness. Please proceed with your testimony, Mr. Davis.

STATEMENT OF JOHN G. DAVIS, DIRECTOR, OFFICE OF NUCLEAR MATERIAL AND SAFEGUARDS, U.S. NUCLEAR REGULATORY COMMISSION, ACCOMPANIED BY ROBERT BURNETT, DIRECTOR, DIVISION OF SAFEGUARDS AND JAMES R. SHEA, DIRECTOR, OFFICE OF INTERNATIONAL PROGRAMS

Mr. DAVIS. Madam Chairman and members of the subcommittee, we are here today at your invitation to discuss NRC's safeguards programs. Your letter of invitation indicated particular interest in devices and techniques used in nuclear safeguards application. I think it is important to note, therefore, that NRC's research and technical assistance programs are not generally intended to develop safeguards-related hardware. We look to the executive branch and the private licensed commercial nuclear industry for such development.

The main purpose of NRC's research and technical assistance programs is to develop technical information which will aid the staff and commission in resolving regulatory issues and provide a sound basis for NRC's regulatory requirements. In fact, it is the commission's policy to allow domestic licensees considerable freedom in designing their own safeguards systems, as long as they satisfy NRC's regulatory performance requirements.

Under the Atomic Energy Act of 1954 and the Energy Reorganization Act of 1974 the NRC requires safeguards in licensed domestic activities to assure protection of the public health and safety and the common defense and security. To accomplish this, NRC requires that measures be taken to deter, prevent, and respond to the unauthorized possession or use of special nuclear material and to protect against sabotage of nuclear facilities. In general, safeguards for fuel cycle facilities emphasize protection against theft or diversion of special nuclear material while those for power reactors stress protection against radiological sabotage.

In the international safeguards area, NRC cooperates with the Department of State, ACDA, and DOE in support activities coordinated through the Action Plan Working Group and the Technical Support Coordinating Committee to improve international safeguards. Since 1978 NRC's role in the group has been to carry out numerous technical assistance and direct support activities, including the following: Sponsored a technical objectives study on goals of IAEA safeguards and associated resource implications; sponsored related studies to identify design features which improve IAEA safeguards at light water reactors, mixed-oxide fuel fabrication facilities and reprocessing plants; provided NRC staff to assist the IAEA in analyzing inspection results and developing quality assurance programs; assisted the IAEA in an information reporting exercise to develop a prototype facility reporting system; participated in IAEA training courses for foreign officials and technical experts; and participated on the steering committee of the now completed

TASTEX program to field test advanced safeguards instrumentation and approaches at the Japanese reprocessing plant at Tokai.

The subcommittee asked us to address several issues, including adequacy of equipment and techniques, R&D programs, interagency coordination, and long-range plans for improving safeguards. With regard to the adequacy of present nondestructive assay and containment and surveillance devices and techniques, safeguards areas which continue to require improvement involve materials measurement and accountability, protection against insider sabotage at reactors, and IAEA safeguards. Measurement technology has still not reached a sufficient level to achieve a "closed material balance" based on measurements for certain classes of materials in bulk processing facilities.

Recognizing limitations of material measurements, especially nondestructive assay, proposed domestic regulatory reforms are being developed for high-enriched uranium and plutonium that will emphasize more timely detection and loss resolution, consistent with research and technical assistance studies of process monitoring concepts. With regard to power reactors, an issue of continuing concern to NRC is protection against sabotage by an insider. Related research and technical assistance have focused upon the definition and identification of vital areas and components at power reactors. The IAEA has identified a number of issues which need resolution to provide improvements in the IAEA safeguards program.

Among the main issues identified by the IAEA are the limited manpower of the inspectorate, restrictions placed by some States on the acceptance of IAEA inspectors, and the availability of suitable instruments. With regard to the instruments, nondestructive assay equipment has not been fully developed and field tested for some forms and types of materials, and currently utilized surveillance devices have limited reliability.

With regard to the scope, effectiveness, and costs of NRC's R&D programs concerning the development of safeguards equipment and techniques, as I previously stated, the main purpose of NRC's research and technical assistance programs is to develop technical information which will provide a sound basis for regulatory requirements. Current safeguards research and technical assistance is oriented toward NRC's regulations and guides. For example, domestic licensees are now completing NRC-required upgrading of safeguards in power reactors and fuel facilities. Associated with those NRC requirements published in title 10, part 73 of the Code of Federal Regulations were research and technical assistance contractual efforts. Products of those contractual efforts provided licensee guidance on closed-circuit television systems, intrusion alarm systems, site security personnel training, alarm station design, work rules to enhance safeguards, emergency power supplies for physical security systems, hardening of SNM storage facilities, and vehicle access and search. Safeguards for spent fuel shipments provide another interesting example of regulatory research. Because of large uncertainties in predicting consequences resulting from explosive sabotage of spent fuel shipments, both NRC and DOE sponsored research programs to reduce the margins of uncertainties.

The NRC program, initiated in 1979, consisted of experiments that used scaled-down explosives against simulated shipping casks containing irradiated material. The DOE program used a full-scale explosive charge against a full-scale cask containing unirradiated fuel. The programs were completed in 1982 and final reports are expected by the end of the year. Results indicate that consequences would be considerably less than predicted earlier. These results are now being reviewed for regulatory implications. NRC's budget for fiscal year 1982 included $3.5 million for safeguards technical assistance and $3.1 million for research.

The extent of NRC's program coordination: NRC has a Safeguards Technical Assistance and Research Coordinating Group, with members of each cognizant office to provide interoffice coordination for the safeguards research program within NRC. This group is responsive to the NRC's national program manager for domestic safeguards, and protects against duplications and overlap and assures program relevance of contracted projects. NRC's projects are also coordinated with other agencies of Government. For example, every year the NRC staff formally transmits descriptions of proposed projects to DOE and DOD for coordination. We receive formal written assurances from these agencies that we are not duplicating their projects.

The NRC is not involved in any safeguards technological agreements with other nations. However, as I mentioned earlier, the NRC does participate in international safeguards programs through the Action Plan Working Group and the Technical Support Coordinating Committee.

The Technical Support Coordinating Committee was organized in 1976 to manage the U.S. Program for Technical Assistance to IAEA Safeguards. This program, funded by the Department of State under the Foreign Assistance Act, provides direct technical support to the IAEA. The largest program effort continues to address the issue of equipment for inspector verification of nuclear materials. More than 20 kinds of equipment are now in the hands of IAEA for test, demonstration, or operational use. This year a major part of this program effort involves field testing and placing into routine use equipment developed and supplied by the United States to the IAEA; preparation of training and maintenance manuals; provision of hands-on training to IAEA employees; and other types of technical backup needed to qualify new instrumentation and equipment for routine inspection use.

The NRC is not aware of any particular problems being encountered in getting advanced safeguards equipment and techniques into routine use domestically. In support of IAEA, implementation plans have been formulated and are being exercised to facilitate the routine use of advanced safeguard equipment and techniques in the IAEA inspection program.

Future NRC research will emphasize new safeguards concepts, human factors, support to regional operations, and examination of foreign safeguards technology. Future technical assistance to support material control and accountability will include work to improve statistical treatment of materials accounting data and to develop an automated material accounting statistic system permitting independent evaluation of material balance and process data.

Planned NRC technical assistance projects related to IAEA include a study of design features to facilitate IAEA safeguards and provisions of assistance to strengthen IAEA safeguards in facilities having most sensitive proliferation concerns. The results of research to assist in developing design criteria for future nuclear powerplants have recently been published. Three follow-on reports which discuss damage control measures and potential sabotage protection design changes for existing reactors are currently being published. Additional research has been initiated in fiscal year 1982 to better model system interactions and common mode failures which could result from acts of sabotage. The results of this research project, which will extend through fiscal year 1985, will be used in assessing the effectiveness of current NRC regulations to protect against sabotage by an insider.

NRC's safeguards research and technical assistance programs are designed to develop technical information which bears on regulatory issues rather than to develop safeguards equipment. Our research programs have been sharply focused and have been declining steadily in cost over the last 5 years. That is illustrated in a chart accompanying this statement. However, NRC's is domestic safeguards research programs, as proposed in the current budget, are considered adequate to meet presently perceived needs. Also, to the extent resources permit, the Commission is prepared to continue to assist the executive branch in strengthening IAEA safeguards. This concludes my statement and I would be pleased to respond to questions from the subcommittee.

[The prepared statement of Mr. Davis follows:]

TESTIMONY OF NRC
BEFORE THE SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION OF THE COMMITTEE ON SCIENCE AND TECHNOLOGY

UNITED STATES HOUSE OF REPRESENTATIVES

AUGUST 3, 1982

Madam Chairman, members of the Subcommittee, we are here today at your invitation to discuss NRC's safeguards programs. Your letter of invitation indicated particular interest in devices and techniques used in nuclear safeguards applications. I think it is important to note, therefore, that NRC's research and technical assistance programs are not generally intended to develop safeguards-related hardware. We look to the Executive Branch and the private licensed commercial nuclear industry for such development.

The main purpose of NRC's research and technical assistance programs is to develop technical information which will aid the staff and Commission in resolving regulatory issues and provide a sound basis for NRC's regulatory requirements. In fact, it is the Commission's policy to allow domestic licensees considerable freedom in designing their own safeguards systems as long as they satisfy NRC's regulatory performance requirements.

NRC SAFEGUARDS PROGRAMS

Under the Atomic Energy Act of 1954 and the Energy Reorganization Act of 1974 the NRC requires safeguards in licensed domestic activities to assure protection of the public health and safety and the common defense and security. To accomplish this, NRC requires that measures be taken to deter, prevent and respond to the unauthorized possession or use of special nuclear material, and to protect against sabotage of nuclear facilities. In general, safeguards for fuel cycle facilities emphasize protection against theft or diversion of special nuclear material (SNM), while those for power reactors stress protection against radiological sabotage.

In the international safeguards area, NRC cooperates with Department of State, ACDA and DOE in support activities coordinated through the Action Plan Working Group and the Technical Support Coordinating Committee to improve international safeguards. Since 1978, NRC's role in the Group has been to carry out numerous technical assistance and direct support activities, including the following:

- Sponsored a technical objectives study on goals of IAEA safeguards and associated resource implications.
- Sponsored related studies to identify design features which improve IAEA safeguards at light water reactors, mixed-oxide fuel fabrication facilities, and reprocessing plants.
- Provided NRC staff to assist the IAEA in analyzing inspection results and developing quality assurance programs.

- Assisted the IAEA in an information reporting exercise to develop a prototype facility reporting system.
- Participated in IAEA training courses for foreign officials and technical experts.
- Participated on the steering committee for the now completed TASTEX program to field test advanced safeguards instrumentation and approaches at the Japanese reprocessing plant at Tokai.

SPECIFIC ISSUES

The Subcommittee asked us to address several issues including adequacy of equipment and techniques, R&D programs, interagency coordination, and long-range plans for improving safeguards.

Adequacy of the present non-destructive assay equipment, and containment and and surveillance devices and techniques being used domestically by the International Atomic Energy Agency

Safeguards areas which continue to require improvement involve materials measurement and accountability, protection against "insider" sabotage at reactors and IAEA safeguards.

Measurement technology has still not reached a level sufficient to achieve a "closed material balance" based on measurements for certain classes of materials in bulk processing facilities. Recognizing limitations of material measurements, especially non-destructive assay (NDA), proposed domestic regulatory reforms are being developed for high-enriched uranium and plutonium that will emphasize more timely detection and loss resolution, consistent with research and technical assistance studies of process monitoring concepts.

With regard to power reactors, an issue of continuing concern to NRC is protection against sabotage by an "insider". Related research and technical assistance have focused upon the definition and identification of vital areas and components at power reactors.

The IAEA has identified a number of issues which need resolution to provide improvements in the IAEA safeguards program. Among the main issues identified by the IAEA are the limited manpower of the inspectorate, restrictions placed by some States on the acceptance of IAEA inspectors, and availability of suitable instruments. With regard to the instruments, non-destructive assay equipment has not been fully developed and field tested for some forms and types of materials and currently-utilized surveillance devices have limited reliability.

Scope, Effectiveness, and cost of the NRC's R&D programs to develop new or improved safeguards equipment and techniques

As I stated previously, the main purpose of NRC's research and technical assistance programs is to develop technical information which will provide a sound basis for regulatory requirements.

Current safeguards research and technical assistance is oriented towards NRC's regulations and guides. For example, domestic licensees are now completing NRC-required upgrading of safeguards in power reactors and fuel facilities. Associated with those NRC requirements published in Title 10 Part 73 of the Code of Federal Regulations were research and technical assistance contractual efforts. Products of those contractual efforts provided licensee guidance on closed-circuit television systems, intrusion alarm systems, site security personnel training, alarm station design, work rules to enhance safeguards, emergency power supplies for physical security systems, hardening of SNM storage facilities, and vehicle access and search.

Safeguards for spent fuel shipments provide another interesting example of regulatory research. Because of large uncertainties in predicted consequences resulting from explosive sabotage of a spent fuel shipment, both NRC and DOE sponsored research programs to reduce the margins of uncertainties. The NRC program, initiated in 1979, consisted of experiments that used scaled-down explosives against simulated shipping casks containing irradiated material. The DOE program used a full-scale explosive charge against a full-scale cask containing unirradiated fuel. The programs were completed in 1982 and final reports are expected by the end of the year. Results indicate that consequences would be considerably less than predicted earlier. These results are now being reviewed for regulatory implications.

NRC's budget for fiscal year 1982 included 3.5 million dollars for safeguards technical assistance and 3.1 million dollars for research.

Extent to which the NRC's programs are coordinated with programs in other agencies and departments, as well as with other nations through existing technological agreements

NRC has a Safeguards Technical Assistance and Research Coordinating (STAR) Group, with members from each cognizant office to provide inter-office coordination for the safeguards research program within NRC. The STAR Group is responsive to NRC's national program manager for domestic safeguards and protects against duplications and overlap and assures program relevance of contracted projects.

NRC's projects are also coordinated with other agencies of government. For example, every year the NRC staff formally transmits descriptions of proposed projects to DOE and DOD for coordination. We receive formal written assurance from these agencies that we are not duplicating their projects.

The NRC is not involved in any safeguards technological agreements with other nations. However, as I mentioned earlier, the NRC does participate in international safeguards programs through the Action Plan Working Group and the

Technical Support Coordinating Committee. The Technical Support Coordinating Committee was organized in 1976 to manage the U.S. Program for Technical Assistance to IAEA Safeguards (POTAS). This program, funded by Department of State under the Foreign Assistance Act, provides direct technical support to the IAEA. The largest POTAS effort continues to address the issue of equipment for inspector verification of nuclear materials. More than 20 kinds of equipment are now in the hands of the IAEA for test, demonstration, or operational use. This year a major part of the POTAS effort involves field testing and placing into routine use equipment developed and supplied by the U.S. to the IAEA; preparation of training and maintenance manuals; provision of "hands-on training" to IAEA employees and other types of technical backup needed to qualify new instrumentation and equipment for routine inspection use.

Problems being encountered in getting advanced safeguards equipment and techniques into routine use domestically and by the International Atomic Energy Agency

The NRC is not aware of any particular problems being encountered in getting advanced safeguards equipment and techniques into routine use domestically. In support of the IAEA, implementation plans have been formulated and are being exercised to facilitate the routine use of advanced safeguards equipment and techniques in the IAEA inspection program.

NRC's long range plans for improving domestic and international safeguards equipment and techniques

Future NRC research will emphasize new safeguards concepts, human factors, support to regional operations, and examination of foreign safeguards technology.

Future technical assistance to support material control and accountability will include work to improve statistical treatment of materials accounting data and to develop an Automated Material Accounting Statistics System (AMASS) permitting independent evaluation of material balance and process data.

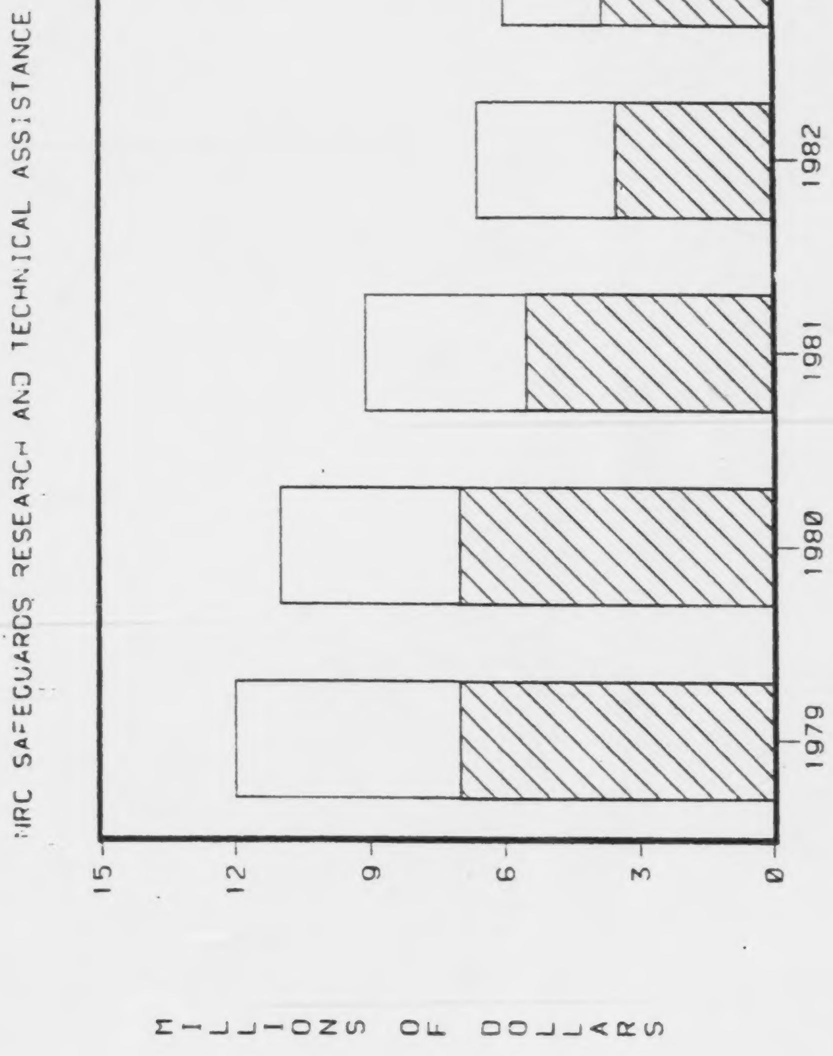
Planned NRC technical assistance projects related to IAEA include a study of design features to facilitate IAEA safeguards and provision of assistance to strengthen IAEA safeguards in facilities having most sensitive proliferation concerns.

The results of research to assist in developing design criteria for future nuclear power plants have recently been published. Three follow-on reports which discuss damage control measures and potential sabotage protection design changes for existing reactors are currently being published. Additional research has been initiated in FY 1982 to better model system interactions and common mode failures which could result from acts of sabotage. The results of this research project, which will extend through FY 1985, will be used in assessing the effectiveness of current NRC regulations to protect against sabotage by an insider.

CONCLUSION

NRC's safeguards research and technical assistance programs are designed to develop technical information which bears on regulatory issues rather than to develop safeguards equipment. Our research programs have been more sharply focused and have been declining steadily in cost over the last five years, as illustrated in the chart accompanying my written statement. However, NRC safeguards research programs, as proposed in the current budget, are considered adequate to meet presently perceived needs.

This concludes my statement. I would be pleased to respond to questions from the Subcommittee.


NRC SAFEGUARDS RESEARCH AND TECHNICAL ASSISTANCE
15
12
9
6
3
0
MILLIONS OF DOLLARS
1979
1980
1981
1982
1983

Mrs. **Bouquard**. Thank you so very much Mr. Davis. Dr. Sessoms, would you proceed with your testimony?

[A biographical sketch of Dr. Sessoms follows:]

BIO

ALLEN LEE SESSOMS

Born in New York City on 17 November 1946

Education - All degrees in Physics

- Union College (N.Y.) B.S. (honors) 1968
- University of Washington, M.S. 1969
- Yale University, M.Phil - 1971, Ph.D. 1972

Fellowships

Ford Foundation Travel & Study Grant 1973-1975
Alfred P. Sloan Foundation Fellow 1977-1981

Experience

- Post Doctoral Research Fellow - Brookhaven National Laboratory 1972-1973
- Scientific Associate, European Center for Nuclear Research (CERN) 1973-1975
- Faculty, Harvard University 1975-1981
- Department of State, Office of Nuclear Technology and Safeguards 1979-Present

Professional Societies

Society of Sigma Xi
American Physical Society
American Association for the Advancement of Science
New York Academy of Sciences

STATEMENT OF DR. ALLEN L. SESSOMS, ACTING DIRECTOR, OFFICE OF NUCLEAR TECHNOLOGY AND SAFEGUARDS, U.S. DEPARTMENT OF STATE

Dr. SESSOMS. Madam Chairman, subcommittee members, thank you for the opportunity to appear before this subcommittee to discuss certain technical aspects of safeguards of the International Atomic Energy Agency safeguards system.

As President Reagan emphasized in his July 1981 statement, IAEA safeguards are an important element of U.S. nonproliferation policy. The United States is committed to—and I quote the President—"Strongly support and continue to work with other nations to strengthen the IAEA to provide for an improved international safeguards regime." We, I believe, are living up to that commitment.

Your letter of invitation identified a number of issues in which the committee has expressed an interest. Before addressing each of these topics, I think it would be useful to describe the current State Department efforts to improve the technical aspects of IAEA safeguards and comment on the policy framework within which those efforts are being pursued.

IAEA safeguards are accepted voluntarily by countries as a technical means of demonstrating their political commitment to use civil nuclear materials and facilities only for their stated peaceful purposes. In order to give substance to that commitment, safeguards must be technically adequate as you Madam Chairman, have already articulated.

In facilities currently under safeguards, the IAEA has the technical capability—that is, the techniques and instruments—to apply safeguards effectively. However, in some cases this may require more manpower and equipment than is currently available. It is, however, important to note that not only instruments, hardware and software, must be available to the IAEA but also that the legal mechanisms and subsidiary arrangements for using the instruments must also be in place if safeguards are to be effective.

In addition to having the necessary equipment and developing required technical procedures, the IAEA must ensure that the prescribed procedures are carried out effectively by inspectors in the field. Inspectors must be trained and their skills continuously updated and improved. Timely analysis and reporting of inspection results must be improved in order to more effectively monitor inspector actions. Software must be developed and put into routine use, reporting procedures must be standardized, and a management system must be in place that facilitates the flow of information to the Deputy Director General for Safeguards and key members of the staff with authority to solve problems that may arise. In each of these areas management tools are being developed and implemented and remedies sought where problems exist. The U.S. program of technical assistance to IAEA safeguards, which we call POTAS, is funded through the Department of State and addresses all of these areas. Since its inception in 1976, 213 individual projects have been completed and over 50 are currently underway. To date, the United States has committed over $27 million for this effort. Approximately 40 professionals in the United States and 17 experts provided cost free to the IAEA are currently involved in POTAS.

Fiscal year 1982 expenditures are about $4 million. I shall try to outline the types of work being conducted and their scope. I would be pleased to elaborate during the question period. In the area of nondestructive assay equipment and containment and surveillance devices, significant progress has been made by the IAEA in improving its capabilities in the last few years and during this current fiscal year in particular. Through POTAS, an entire family of neutron coincidence counting instruments have been developed and are being brought into routine use by the IAEA. These instruments include devices for use with plutonium and mixed-oxide pins and experimental fuel assemblies highly enriched uranium metal low-enriched uranium power reactor fuel assemblies, fast breeder reactor fuel assemblies, and other assemblies made of uranium and plutonium. This family of instruments was developed at the Los Alamos National Laboratory. All but the last, which is primarily for fast breeder reactor assemblies, are being brought into routine use by the IAEA. These instruments give the IAEA the ability to independently verify declared material content and quantity. This is essential if the IAEA is to achieve its objectives. Still other instruments in this family are under development under POTAS.

Another surveillance or nondestructive assay instrument developed through POTAS, and one that is in very much demand by IAEA inspectors, is the Javelin Cerenkov night viewing device. This device allows the inspector to see the characteristic blue glow from spent power reactor fuel when the fuel is underwater, even when that glow has become faint because the spent fuel has been in storage for several years. This instrument permits the IAEA inspector to confirm that the inspected fuel assemblies contain spent reactor fuel, thereby covering one of the easiest diversion paths at power reactors—that of substituting dummy fuel.

International collaboration with our close allies has also been part of our efforts to develop new instruments and techniques. For example, the K-edge densitometer was developed under POTAS by the Los Alamos National Laboratory in collaboration with Japan during the Tokai advanced safeguards technology exercise. This device is being brought into routine use by the IAEA at the Tokai reprocessing plant in Japan. In fact, I expect now or at least by the end of this month that it will be routinely used by the agency. Under POTAS, the United States has developed and/or improved several optical surveillance systems, including both film and TV cameras. A very advanced system that is currently under test and evaluation by the IAEA is the surveillance television and recordifg system, called STAR, developed by the Sandia Laboratories. I expect that many of these instruments and techniques will be covered tomorrow during your session, so I won't take time to elaborate.

Another instrument developed through POTAS for TASTEX and going into routine use at the Tokai Mura reprocessing plant is the automated electromanometer for the measurement of levels of solutions in accountability vessels. This instrument, developed at the Brookhaven National Laboratory, reduces the burden to the inspector in monitoring plutonium storage tanks at reprocessing plants, since it provides a continuous automatic measurement that is read on-line by computer.

All of these efforts have had a significant positive impact on IAEA safeguards. However, given the increasing number of new and larger facilities coming under safeguards, the IAEA's need for technical assistance will continue. The State Department's efforts in this area are closely coordinated with other interested United States Government agencies. Policy guidance and coordination with overall U.S. nonproliferation efforts are provided by the interagency steering group, comprised of DOE, NRC, ACDA, NSC staff, and chaired by State. POTAS also enjoys a significant degree of coordination among Washington agencies. POTAS is directed by the Technical Support Coordinating Committee which is chaired by State and includes representatives of DOE, ACDA, and the NRC. This committee meets approximately once a month to review the progress of the program and to resolve problems that may arise.

The detailed implementation of the program, as Mr. Caudle has already pointed out, has been delegated by the State Department to the Department of Energy. In my opening remarks I discussed the scope and cost of the State Department's efforts to improve the application of IAEA safeguards. Our program was the first of its kind and has served as the model for newer programs such as those of Japan, the Federal Republic of Germany, the United Kingdom, Canada, Australia, and the Soviet Union. EURATOM now also has a joint program with the IAEA.

While individuals from the United States have gotten to know their counterparts in other governments and have established good working relationships, the number of programs has grown too large for ad hoc coordination. Thus, following an IAEA safeguards symposium in November, the coordinators of the various national programs will meet in Vienna for a week to exchange views and possibly to develop joint projects.

Most of the equipment and techniques developed through POTAS and other support programs are state-of-the-art—that is, they utilize new concepts developed in some cases solely for use in international safeguards. IAEA staff cannot be expected to embrace these techniques immediately and put them into routine use. Time and effort are required to train the IAEA staff, to test and evaluate the systems, to make the changes that are necessary to ensure ease of operation even under difficult field conditions, and to incorporate the equipment and techniques into standard operating procedures.

In recognition of the problems faced by the IAEA in getting instruments and techniques into routine use by the inspectorate, emphasis in POTAS has been shifted from development of instruments and techniques to providing assistance to the IAEA in bringing developed technology into routine use throughout the IAEA safeguards program. We are working closely with the IAEA and developers of equipment, mainly the national labs, to complete the demonstration and implementation of equipment and procedures that have already been developed and to bring these into routine use by the inspectorate.

In the long term our increasing attention will have to be focused on ensuring that the IAEA has the tools at its disposal to safeguard the large bulk-handling facilities that will come on-line. This includes reprocessing plants, enrichment plants, mixed-oxide fuel fabrication plants, and plutonium and mixed-oxide fuel storage facilities. Safeguarding these facilities, especially if large, will require incorporating into plant design already identified safeguards measures such as near-real time accountancy if safeguards are to be both effective and utilize the resources available to the IAEA in the most efficient way.

[The prepared statement of Dr. Sessoms follows:]

STATEMENT OF ALLEN L. SESSOMS
ACTING DIRECTOR, OFFICE OF NUCLEAR
TECHNOLOGY AND SAFEGUARDS
U.S. DEPARTMENT OF STATE

before the

SUBCOMMITTEE ON ENERGY RESEARCH AND
PRODUCTION, COMMITTEE ON SCIENCE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES
WASHINGTON, D.C.

on

TECHNICAL ASPECTS OF NUCLEAR NON-PROLIFERATION SAFEGUARDS

AUGUST 3, 1982

MADAME CHAIRMAN:

THANK YOU FOR THE OPPORTUNITY TO APPEAR BEFORE THIS SUBCOMMITTEE TO DISCUSS CERTAIN TECHNICAL ASPECTS OF SAFEGUARDS OF THE INTERNATIONAL ATOMIC ENERGY AGENCY SAFEGUARDS SYSTEM. YOUR LETTER OF INVITATION IDENTIFIED A NUMBER OF ISSUES IN WHICH THE COMMITTEE HAS EXPRESSED INTEREST, INCLUDING: THE ADEQUACY OF PRESENT NONDESTRUCTIVE ASSAY EQUIPMENT AND CONTAINMENT AND SURVEILLANCE DEVICES; THE SCOPE, EFFECTIVENESS, AND COST OF THE STATE DEPARTMENT'S RESEARCH AND DEVELOPMENT PROGRAMS FOR NEW OR IMPROVED SAFEGUARDS EQUIPMENT AND TECHNIQUES; THE EXTENT TO WHICH THE STATE DEPARTMENT'S PROGRAMS ARE COORDINATED WITH PROGRAMS OF OTHER DEPARTMENTS AND AGENCIES, AND OTHER NATIONS; PROBLEMS BEING ENCOUNTERED IN GETTING ADVANCED SAFEGUARDS EQUIPMENT AND TECHNIQUES INTO ROUTINE USE BY THE IAEA; AND THE STATE DEPARTMENT'S LONG-RANGE PLANS FOR IMPROVING IAEA SAFEGUARDS RELATED EQUIPMENT TECHNIQUES.

AS PRESIDENT REAGAN EMPHASIZED IN HIS JULY 1981 STATEMENT, IAEA SAFEGUARDS ARE AN IMPORTANT ELEMENT OF U.S. NUCLEAR NON-PROLIFERATION POLICY. THE UNITED STATES IS COMMITTED TO "STRONGLY SUPPORT AND CONTINUE TO WORK WITH OTHER NATIONS TO STRENGTHEN THE IAEA TO PROVIDE FOR AN IMPROVED INTERNATIONAL SAFEGUARDS REGIME". WE ARE LIVING UP TO THAT COMMITMENT.

BEFORE ADDRESSING EACH OF THESE TOPICS, I THINK IT WOULD BE USEFUL TO DESCRIBE CURRENT STATE DEPARTMENT EFFORTS TO IMPROVE THE TECHNICAL ASPECTS OF IAEA SAFEGUARDS, AND COMMENT ON THE POLICY FRAMEWORK WITHIN WHICH THOSE EFFORTS ARE BEING PURSUED.

IAEA SAFEGUARDS ARE ACCEPTED VOLUNTARILY BY COUNTRIES AS A TECHNICAL MEANS OF DEMONSTRATING THEIR POLITICAL COMMITMENT TO USE CIVIL NUCLEAR MATERIALS AND FACILITIES ONLY FOR THEIR STATED PEACEFUL PURPOSES. IN ORDER TO GIVE SUBSTANCE TO THAT COMMITMENT, SAFEGUARDS MUST BE TECHNICALLY CAPABLE OF MEETING THEIR OBJECTIVE, WHICH IS TO DETECT THE DIVERSION OF MATERIALS OR USE OF FACILITIES FOR OTHER THAN FOR THEIR STATED PEACEFUL PURPOSES, AND TO DETER SUCH DIVERSION BY THE RISK OF EARLY DETECTION.

IN FACILITIES CURRENTLY UNDER SAFEGUARDS, THE IAEA HAS THE TECHNICAL CAPABILITY, E.G. THE TECHNIQUES AND INSTRUMENTS, TO APPLY EFFECTIVE SAFEGUARDS. HOWEVER, IN SOME CASES THIS MAY REQUIRE MORE MANPOWER AND EQUIPMENT

THAN IS CURRENTLY AVAILABLE. IT IS, HOWEVER, IMPORTANT TO NOTE THAT NOT ONLY MUST THE INSTRUMENTS, HARDWARE AND SOFTWARE, BE AVAILABLE TO THE IAEA, BUT ALSO THAT THE LEGAL MECHANISMS AND SUBSIDIARY ARRANGEMENTS FOR USING THOSE INSTRUMENTS MUST ALSO BE IN PLACE IF SAFEGUARDS ARE TO BE EFFECTIVE. FOR EXAMPLE, AT SOME ON-LINE FUELED POWER REACTORS IN STATES WITH NEWER FUEL CYCLE FACILITIES NOT UNDER SAFEGUARDS, SOME ARGUE THAT CIRCUMSTANCES MAY REQUIRE THE AMENDMENT OR AT THE LEAST REINTERPRETATION OF PREVIOUS FACILITY ATTACHMENTS. THE IAEA DIRECTOR GENERAL NOTED THIS BY INFORMING THE BOARD OF GOVERNORS IN SEPTEMBER 1981 THAT THE AGENCY CAN NO LONGER GIVE THE REQUISITE ASSURANCES THAT A DIVERSION HAS NOT OCCURED IN CERTAIN SPECIAL CASES. THESE ISSUES ARE BEING NEGOTIATED BETWEEN THE IAEA AND THE STATES CONCERNED.

IN ADDITION TO HAVING THE NECESSARY EQUIPMENT AND DEVELOPING REQUIRED TECHNICAL PROCEDURES, THE IAEA MUST ENSURE THAT THE PRESCRIBED PROCEDURES ARE CARRIED OUT EFFECTIVELY BY THE INSPECTORS IN THE FIELD. INSPECTORS MUST BE TRAINED AND THEIR SKILLS CONTINOUSLY UPDATED AND

IMPROVED. TIMELY ANALYSIS AND REPORTING OF INSPECTION RESULTS MUST BE IMPROVED IN ORDER TO MORE EFFECTIVELY MONITOR INSPECTOR ACTIONS. SOFTWARE MUST BE DEVELOPED AND PUT INTO ROUTINE USE, REPORTING PROCEDURES MUST BE STANDARDIZED, AND A MANAGEMENT SYSTEM MUST BE IN PLACE THAT FACILITATES THE FLOW OF INFORMATION TO THE DEPUTY DIRECTOR GENERAL FOR SAFEGUARDS AND KEY MEMBERS OF HIS STAFF WITH AUTHORITY TO SOLVE PROBLEMS THAT MAY ARISE. IN EACH OF THESE AREAS MANAGEMENT TOOLS ARE BEING DEVELOPED AND IMPLEMENTED, AND REMEDIES SOUGHT WHERE PROBLEMS EXIST.

THE U.S. PROGRAM OF TECHNICAL ASSISTANCE TO IAEA SAFEGUARDS (POTAS), FUNDED THROUGH THE DEPARTMENT OF STATE, ADDRESSES ALL OF THESE AREAS. SINCE ITS INCEPTION IN 1976, 213 INDIVIDUAL PROJECTS HAVE BEEN COMPLETED AND OVER 50 ARE CURRENTLY UNDERWAY. TO DATE, THE U.S. HAS COMMITTED OVER $27 MILLION TO THIS EFFORT. APPROXIMATELY 40 PROFESSIONALS IN THE U.S. AND 17 EXPERTS, PROVIDED COST FREE TO THE IAEA, ARE CURRENTLY INVOLVED IN POTAS. FY 82 EXPENDITURES ARE ABOUT $4 MILLION.

TO ADEQUATELY DISCUSS ALL OF THE INSTRUMENTS AND TECHNIQUES THAT HAVE BEEN DEVELOPED THROUGH POTAS TO DATE WOULD TAKE MUCH LONGER THAN WE HAVE AVAILABLE HAVE TODAY.

I SHALL TRY TO OUTLINE THE TYPES OF WORK BEING CONDUCTED AND THEIR SCOPE. I WOULD BE PLEASED TO ELABORATE DURING THE QUESTION PERIOD.

IN THE AREA OF NONDESTRUCTIVE ASSAY EQUIPMENT AND CONTAINMENT AND SURVEILLANCE DEVICES SIGNIFICANT PROGRESS HAS BEEN MADE BY THE IAEA IN IMPROVING ITS CAPABILITIES IN THE LAST FEW YEARS AND DURING THIS CURRENT FISCAL YEAR IN PARTICULAR. THROUGH POTAS, AN ENTIRE FAMILY OF NEUTRON COINCIDENCE COUNTING INSTRUMENTS HAS BEEN DEVELOPED AND IS BEING BROUGHT INTO ROUTINE USE BY THE IAEA. OTHER INSTRUMENTS INCLUDE: THE HIGH LEVEL NEUTRON COINCIDENCE COUNTER FOR USE WITH PLUTONIUM AND MIXED OXIDE PINS AND EXPERIMENTAL FUEL ASSEMBLIES; THE ACTIVE WELL COINCIDENCE COUNTER FOR USE WITH HIGH ENRICHED URANIUM METAL; AND THE ACTIVE NEUTRON COINCIDENCE COLLAR FOR USE WITH LOW ENRICHED URANIUM POWER REACTOR FUEL ASSEMBLIES. A PASSIVE NEUTRON COINCIDENCE COLLAR FOR FAST BREEDER REACTOR FUEL ASSEMBLIES IS UNDER DEVELOPMENT. THIS FAMILY OF INSTRUMENTS WAS DEVELOPED AT LOS ALAMOS NATIONAL LABORATORY. ALL BUT THE LAST OF THESE INSTRUMENTS ARE NOW IN ROUTINE USE BY THE IAEA. THESE INSTRUMENTS GIVE THE IAEA THE ABILITY TO INDEPENDENTLY VERIFY DECLARED MATERIAL CONTENT AND QUANTITY. THIS IS ESSENTIAL IF THE IAEA IS TO ACHIEVE ITS OBJECTIVES.

STILL OTHER INSTRUMENTS IN THIS FAMILY ARE UNDER DEVELOPMENT UNDER POTAS. THESE INSTRUMENTS WILL BE USED WITH FAST BREEDER REACTOR FUEL ASSEMBLIES, BULK URANIUM SUCH AS UO2 RODS, HIGHLY ENRICH URANIUM METAL AND SCRAP, AND BULK MOX STORAGE.

ANOTHER SURVEILLENCE/NDA INSTRUMENT DEVELOPED THROUGH POTAS, AND VERY MUCH IN DEMAND BY IAEA INSPECTORS, IS THE JAVELIN CERENKOV NIGHT VIEWING DEVICE. THIS DEVICE ALLOWS THE INSPECTOR TO SEE THE CHARACTERISTIC BLUE CERENKOV GLOW FROM SPENT FUEL EVEN WHEN THAT GLOW HAS BECOME FAINT BECAUSE THE SPENT FUEL HAS BEEN IN THE STORAGE POND FOR SEVERAL YEARS. THIS BLUE GLOW IS PRODUCED BY ELECTRONS, THAT ARE USUALLY GIVEN OFF DURING RADIOACTIVE DECAY, AS THEY PASS THROUGH WATER. IT IS NAMED FOR THE SCIENTIST WHO FIRST DESCRIBED THE PHENOMENON. GENUINE SPENT NUCLEAR REACTOR FUEL EMITS SUCH ELECTRONS. UNIRRADIATED, FRESH, FUEL DOES NOT. THIS INSTRUMENT PERMITS THE IAEA INSPECTOR TO CONFIRM THAT THE INSPECTED FUEL ASSEMBLIES CONTAIN SPENT REACTOR FUEL, THEREBY COVERING ONE OF THE EASIEST DIVERSION PATHS AT POWER REACTORS, THAT OF SUBSTITUTING DUMMY FUEL.

INTERNATIONAL COLLABORATION WITH OUR CLOSE ALLIES HAS ALSO BEEN PART OF OUR EFFORTS TO DEVELOP NEW INSTRUMENTS AND TECHNIQUES. FOR EXAMPLE, THE K-EDGE DENSITOMETER

WAS DEVELOPED UNDER POTAS BY LOS ALAMOS NATIONAL LABORATORY IN COLLABORATION WITH JAPAN DURING THE TOKAI ADVANCED SAFEGUARDS TECHNOLOGY EXERCISE (TASTEX). THIS IS A VERY IMPORTANT NONDESTRUCTIVE ASSAY INSTRUMENT, WHICH IS BEING BROUGHT INTO ROUTINE USE AT THE TOKAI REPROCESSING PLANT IN JAPAN BY THE IAEA THIS MONTH (AUGUST). THIS DEVICE IS USED TO DETERMINE PLUTONIUM CONCENTRATION IN LIQUIDS GIVING THE IAEA THE ABILITY TO MONITOR PLUTONIUM PROCESS FLOWS IN REPROCESSING PLANTS.

UNDER POTAS, THE U.S. HAS DEVELOPED AND/OR IMPROVED SEVERAL OPTICAL SURVEILLENCE SYSTEMS, INCLUDING BOTH FILM AND TV CAMERAS. A VERY ADVANCED SYSTEM THAT IS CURRENTLY UNDER TEST AND EVALUATION BY THE IAEA IS THE SURVEILLENCE TELEVISION AND RECORDING SYSTEM (STAR) DEVELOPED BY THE SANDIA LABORATORY. THIS SYSTEM, HAS SUCH FEATURES AS 16 POINT MOTION DETECTION, 2 REDUNDANT VIDEO RECORDERS, MICROPROCESSOR CONTROLS, AND TWO VIDEO CAMERAS ALL CONTAINED IN A TAMPER RESISTANT HOUSING. FOR SPECIAL CASES, A "SLAVE" RECORDER IS PROVIDED TO PERMIT A SECOND AUTHORITY TO REMOVE A VIDEO CASSETTE FOR REVIEW BY IAEA AND HOST COUNTRY OFFICIALS DURING AN INTERIM PERIOD. THIS IS USEFUL IN EURATOM COUNTRIES WHERE TWO INSPECTORATES JOIN IN VARIOUS VERIFICATION ACTIVITIES.

ANOTHER INSTRUMENT DEVELOPED THROUGH POTAS FOR TASTEX AND GOING INTO ROUTINE USE AT THE TOKAI MURA REPROCESSING PLANT IN JAPAN IS THE AUTOMATED ELECTROMANOMETER FOR THE MEASUREMENT OF LEVELS OF SOLUTIONS IN ACCOUNTABILITY VESSELS. THIS INSTRUMENT, DEVELOPED AT THE BROOKHAVEN NATIONAL LABORATORY, REDUCES THE BURDEN TO THE THE INSPECTOR IN MONITORING PLUTONIUM STORAGE TANKS AT REPROCESSING PLANTS, SINCE IT PROVIDES A CONTINUOUS, AUTOMATIC MEASUREMENT THAT IS READ ON LINE BY A COMPUTER. IT ALSO IMPROVES THE ACCURACY OF MEASUREMENTS, AND SIGNIFICANTLY CONTRIBUTES TO THE IAEA'S ABILITY TO CLOSE THE MATERIAL BALANCE.

ALL OF THESE EFFORTS HAVE HAD A SIGNIFICANT POSITIVE IMPACT ON IAEA SAFEGUARDS; HOWEVER, GIVEN THE INCREASING NUMBER OF NEW AND LARGER FACILITIES COMING UNDER SAFEGUARDS, THE IAEA'S NEED FOR TECHNICAL ASSISTANCE WILL CONTINUE.

THE STATE DEPARTMENT'S EFFORTS IN THIS AREA ARE CLOSELY COORDINATED WITH OTHER INTERESTED US AGENCIES. POLICY GUIDANCE AND COORDINATION WITH OVERALL U.S. NON-PROLIFERATION EFFORTS ARE PROVIDED BY THE INTER-AGENCY STEERING GROUP, COMPRISED OF DOE, NRC, ACDA, NSC STAFF AND CHAIRED BY STATE. POTAS ENJOYS A SIGNIFICANT DEGREE OF COORDINATION AMONG WASHINGTON AGENCIES. POTAS IS DIRECTED BY A TECHNICAL SUPPORT COORDINATING COMMITTEE CHAIRED BY STATE AND INCLUDING REPRESENTATIVES

OF DOE, ACDA, AND THE NRC. THIS COMMITTEE MEETS APRROXIMATELY ONCE A MONTH TO REVIEW THE PROGRESS OF THE PROGRAM AND TO RESOLVE PROBLEMS AS THEY ARISE.

THE DETAILED IMPLEMENTATION OF THE PROGRAM HAS BEEN DELEGATED BY STATE TO DOE. DOE HAS, IN TURN, SET UP THE INTERNATIONAL SAFEGUARDS PROJECT OFFICE (ISPO) AT BROOKHAVEN NATIONAL LABORATORY FOR THE OVERALL TECHNICAL IMPLEMENTATION OF THE PROGRAM. WE HAVE FOUND THIS TO BE A VERY EFFECTIVE AND EFFICIENT SYSTEM. MUCH OF THE ACTUAL DEVELOPMENT WORK IS PERFORMED BY U.S. NATIONAL LABORATORIES, WHICH WERE ESTABLISHED TO PROVIDE TECHNICAL SUPPORT FOR PRIORITY NATIONAL PROGRAMS INVOLVING NUCLEAR TECHNOLOGY. PARTICIPATING LABORATORIES INCLUDE LOS ALAMOS, SANDIA, OAK RIDGE, IDAHO NATIONAL ENGINEERING LAB, ARGONNE, BROOKHAVEN, PACIFIC NORTHWEST LAB, LIVERMORE AND OTHERS.

IN MY OPENING REMARKS I DISCUSSED THE SCOPE AND COSTS OF THE STATE DEPARTMENT'S EFFORTS TO IMPROVE THE APPLICATION OF IAEA SAFEGUARDS. OUR PROGRAM WAS THE FIRST OF ITS KIND AND HAS SERVED AS THE MODEL FOR NEWER PROGRAMS SUCH AS THOSE OF JAPAN, THE FRG, THE U.K,, CANADA, AUSTRALIA AND THE SOVIET UNION. EURATOM NOW ALSO HAS A JOINT PORGRAM WITH THE IAEA.

THE POTAS PROGRAM IS BY FAR THE LARGEST OF THESE EFFORTS. MOST OF THE ADVANCED NONDESTRUCTIVE ASSAY EQUIPMENT NOW AVAILABLE TO THE IAEA WAS DEVELOPED THROUGH POTAS.

WE ARE WORKING WITH JAPAN, AUSTRALIA, AND WITH THE U.K., THE FRG AND THE NETHERLANDS (THE URENCO GROUP) ON THE HEXAPARTITE SAFEGUARDS PROJECT, WHICH IS AIMED AT DEVELOPING SAFEGUARDS APPROACHES TO GAS CENTRIFUGE ENRICHMENT PLANTS, INCLUDING SAFEGUARDS RESEARCH, DEVELOPMENT AND DEMONSTRATION. THIS PROJECT IS NEARING COMPLETION. WE EXPECT TO MAKE RECOMMENDATIONS TO THE IAEA BY THE END OF THE YEAR.

WHILE INDIVIDUALS FROM THE US HAVE GOTTEN TO KNOW THEIR COUNTERPARTS IN OTHER GOVERNMENTS AND HAVE ESTABLISHED GOOD WORKING RELATIONSHIPS, THE NUMBER OF PROGRAMS HAS GROWN TOO LARGE FOR SUCH AD HOC COORDINATION. THUS, FOLLOWING AN IAEA SAFEGUARDS SYMPOSIUM IN NOVEMBER, THE COORDINATORS OF THE VARIOUS NATIONAL PROGRAMS WILL MEET IN VIENNA FOR A WEEK TO EXCHANGE VIEWS AND POSSIBLY TO DEVELOP JOINT PROJECTS.

MOST OF THE EQUIPMENT AND TECHNIQUES DEVELOPED THROUGH POTAS AND OTHER SUPPORT PROGRAMS ARE "STATE OF THE ART", THAT IS THEY UTILIZE NEW CONCEPTS DEVELOPED IN SOME CASES SOLELY FOR USE IN INTERNATIONAL SAFEGUARDS. IAEA STAFF CANNOT BE EXPECTED TO EMBRACE THEM IMMEDIATELY AND PUT THEM INTO ROUTINE USE. TIME AND EFFORT ARE REQUIRED TO TRAIN THE IAEA STAFF, TO TEST AND EVALUATE THE SYSTEMS, TO MAKE THE CHANGES THAT ARE NECESSARY TO ENSURE EASE OF OPERATION EVEN UNDER DIFFICULT FIELD CONDITIONS, AND TO INCORPORATE THE EQUIPMENT AND TECHNIQUES INTO STANDARD OPERATING PROCEDURES.

IN RECOGNITION OF THE PROBLEMS FACED BY THE IAEA IN GETTING INSTRUMENTS AND TECHNIQUES INTO ROUTINE USE BY THE INSPECTORATE, EMPHASIS IN POTAS HAS BEEN SHIFTED FROM DEVELOPMENT OF INSTRUMENTS AND TECHNIQUES TO PROVIDING ASSISTANCE TO THE IAEA IN BRINGING DEVELOPED TECHNOLOGY INTO ROUTINE USE THORUGHOUT THE SAFEGUARDS PROGRAM. WE ARE WORKING CLOSELY WITH THE IAEA AND THE DEVELOPERS OF EQUIPMENT, MAINLY THE NATIONAL LABS, TO COMPLETE THE DEMONSTRATION AND IMPLEMENTATION OF THE EQUIPMENT AND PROCEDURES THAT HAVE ALREADY BEEN DEVELOPED AND TO BRING THESE INTO ROUTINE USE BY THE INSPECTORATE. WE ARE ALSO WORKING WITH THE IAEA TO REDUCE THE TIME REQUIRED TO DEVELOP AND IMPLEMENT INSTRUMENTS AND TECHNIQUES THAT MAY BE REQUESTED BY THE IAEA IN THE FUTURE.

IN THIS REGARD WE HAVE BEGUN TO ACQUIRE FIRST-HAND

EXPERIENCE OF THE PROBLEMS FACED BY IAEA INSPECTORS IN THE FIELD THROUGH IMPLEMENTATION OF THE US/IAEA SAFEGUARDS AGREEMENT. UNDER THIS AGREEMENT THE IAEA IS CONDUCTING INSPECTIONS AT TWO POWER REACTORS, TROJAN AND RANCHO SECO, AND THE EXXON LOW ENRICHED URANIUM FUEL FABRICATION PLANT IN RICHLAND, WASHINGTON. THIS EXPERIENCE SHOULD ENABLE US WORK MORE EFFECTIVELY WITH THE INSPECTORATE TO SOLVE PROBLEMS RELATED TO THE UTILIZATION OF NEW EQUIPMENT.

IN THE LONG TERM, OUR INCREASING ATTENTION WILL BE HAVE TO BE FOCUSED ON ENSURING THAT THE IAEA HAS THE TOOLS AT ITS DISPOSAL TO SAFEGUARD THE LARGE BULK HANDLING FACILITIES THAT WILL BE COMING ON LINE. THIS INCLUDES: REPROCESSING PLANTS, ENRICHMENT PLANTS, MIXED OXIDE FUEL FABRICATION PLANTS, AND PLUTONIUM AND MOX STORAGE FACILITIES. SAFEGUARDING THESE FACILITIES, ESPECIALLY IF LARGE, WILL REQUIRE INCORPORATING INTO THE PLANT DESIGN ALREADY IDENTIFIED SAFEGUARDS MEASURES SUCH AS NEAR-REAL TIME ACCOUNTANCY

IF SAFEGUARDS ARE TO BE BOTH EFFECTIVE AND UTILIZE THE RESOURCES AVAILABLE TO THE IAEA IN THE MOST EFFICIENT WAY.

WORK IS ALREADY IN PROGRESS IN ALL OF THESE AREAS, THROUGH POTAS AND OTHER EFFORTS, SUCH AS THOSE OF DOE AND ACDA, SUPPORTED BY THE USG. WE EXPECT THESE EFFORTS TO EXPAND IN THE FUTURE. FOR EXAMPLE, WE EXPECT TO WORK CLOSELY WITH JAPAN IN DEVELOPING TECHNIQUES FOR SAFEGUARDING LARGE REPROCESSING PLANTS. WE HAVE BEEN, AND WILL CONTINUE TO, WORK WITH THE IAEA, ACDA AND OTHERS IN SUPPORT OF THE WORK ON REMOTE CONTINUAL VERIFICATION (RECOVER). THIS IS THE SYSTEM THAT REMOTELY MONITORS CERTAIN SPECIALLY DESIGNED SAFEGUARDS INSTRUMENTS SUCH AS CAMERAS AND SEALS TO INSURE THEIR PROPER OPERATION EVEN WHEN IAEA INSPECTORS ARE NOT PRESENT. IT COULD, THEREFORE, BE USEFUL IN LENDING ADDED ASSURANCE TO SAFEGUARDS PROCEDURES WHILE POTENTIALLY REDUCING IAEA MANPOWER REQUIREMENTS. WE ALSO EXPECT TO HELP SUPPORT THE TRANSEAVER DEVELOPMENT AND DEMONSTRATION EFFORT SPEARHEADED BY ACDA. TRANSEAVER USES THE RECOVER CONCEPT AND HARDWARE TO ALLOW CONTINUAL SURVEILLENCE OF SPECIALLY DESIGNED IAEA SAFEGUARDS INSTRUMENTS DURING THE SHIPMENT OF MATERIALS BY SEA. THIS CONCEPT IS NOW GOING INTO THE TEST AND EVALUATION PHASE.

ATTENTION WILL CONTINUE TO BE FOCUSED ON HELPING THE IAEA SOLVE PROBLEMS AS THEY ARISE IN PARTICULAR FACILITIES. THIS COULD INCLUDE SYSTEM STUDIES, HARDWARE DEVELOPMENT OR/AND HARDWARE PROCUREMENT.

IN SUM THE STATE DEPARMTENT'S EFFORTS IN SUPPORT OF IAEA SAFEGUARDS ARE MULTIFACETED AND COVER ALL AREAS OF CONCERN. WE ARE COMMITTED TO CONTINUING TO IMPROVE SAFEGUARDS SO THAT NEW TECHNOLOGIES CAN BE BROUGHT TO BEAR AND THE SAFEGUARDS SYSTEM ADAPTED TO DEALING WITH EXPANDED PEACEFUL USES OF NUCLEAR ENERGY. THIS WILL INLCUDE THE INAUGURATION OF SEVERAL SENSITIVE FACILITIES SUCH AS REPROCESSING PLANTS LARGER THAN THOSE CURRENTLY IN EXISTENCE AND MIXED OXIDE FUEL FABRICATION FACILITIES. SUCH FACILITIES ARE ADMITTEDLY MORE DIFFICULT TO SAFEGUARD ADEQUATELY THAN THOSE CURRENTLY ON LINE.

IN THIS EFFORT, AND THOSE I HAVE DESCRIBED PREVIOUSLY, WE SHALL CONTINUE TO WORK CLOSELY WITH THE IAEA AND WITH KEY IAEA MEMBER COUNTRIES.

Mrs. Bouquard. Thank you very much, Dr. Sessoms. I appreciated your testimony.

Dr. Menzel, would you please proceed with your testimony?

STATEMENT OF DR. JOERG H. MENZEL, CHIEF, NUCLEAR SAFEGUARDS TECHNOLOGY DIVISION, BUREAU OF NUCLEAR AND WEAPONS CONTROL, U.S. ARMS CONTROL AND DISARMAMENT AGENCY

Dr. Menzel. Thank you. It is an honor for me to appear before this subcommittee today to discuss the external research program for international safeguards, funded and implemented by the United States Arms Control and Disarmament Agency. In my oral presentation I shall address in abbreviated form the scope, effectiveness, and cost of our research program; the mechanisms to coordinate our program with those of other U.S. agencies, other countries, and the International Atomic Energy Agency; and, last, our plans for next year. With your permission, I shall provide for the record detailed information on individual projects and expenditures.

Mrs. Bouquard. Without objection, it will be made a part of the record, Dr. Menzel.

Dr. Menzel. Thank you. ACDA's external research program for international safeguards, initiated in 1968, is specifically designed to provide relevant information on international safeguards to U.S. policymakers, to explore innovative safeguards approaches for potential use by the IAEA, and to support the U.S. effort in strengthening IAEA safeguards. The program is characterized by exploring the feasibility of new concepts and new technology, often with the close cooperation of one or more foreign governments and/or the IAEA.

Our current research program for international safeguards is planned for $836,000 or 41 percent of ACDA's total external research budget. The allocation of safeguards from our total research funds has remained fairly constant over the last 6 years, when one takes into consideration the safeguards programs of other U.S. agencies and the fact that fluctuations do result from variations in the start of specific projects. An overview of the relevant data for the period of fiscal year 1976 through fiscal year 1982 is included in table 1 of the written statement.

The scope of our safeguards research program is broad. Individual projects of the program fall within four major project areas, namely: fuel cycles and facilities; systems development; instruments and methods; and remote verification. An overview of the project area allocations for fiscal year 1976 to fiscal year 1982 is shown in table 2 of the written statement. The individual project titles and amounts for fiscal year 1982 are listed in table 3.

Within the broad scope of the program, the nature of individual projects is diverse. It ranges from development of fiber-optic seals to the design of features for heavy water production plants to facilitate the application of IAEA safeguards; from providing experts on a regular basis to the IAEA to assist in safeguards system development to the demonstration of instant-film, remote-diagnostic surveillance systems; from studying the feasibility of remote verification techniques to documenting the detailed negotiating history of IAEA safeguards documents. To illustrate this point, table 4 of the written statement provides the individual project titles for fiscal year 1968 through fiscal year 1975, and those for fiscal year 1976 through fiscal year 1981 are listed in table 5.

ACDA's safeguards research program is carried out by a cadre of physical science officers dedicated to IAEA safeguards matters and thoroughly versed in nuclear technology and international safeguards. These professionals keep abreast of the latest developments in safeguards concepts and technology in the United States and abroad, and they assure proper coordination of our program with that of other U.S. agencies and the IAEA. This is accomplished through daily interaction with cognizant U.S. agencies and with individuals in the international safeguards community; through formal U.S. interagency groups which meet on a regular basis and were already mentioned by others; through participation in meetings of professional societies and in various IAEA-sponsored technical groups and symposia; and through the framework of bilateral consultations with other governments. The frequent interaction of our staff with the Department of Safeguards of the IAEA continues to serve as the focal point of our work.

We believe our safeguards research program to be effective. Naturally, as in any research program oriented toward innovative concepts and the use of new technologies, it is not always possible to predict the degree of utility or the impact of a particular product. Sometimes it does take years for a new idea to bear fruit. ACDA's pioneering work in fiber-optic seals provided the basis for recent R&D efforts sponsored by others. Our work on isotopic correlation techniques for use at reprocessing plants has resulted in techniques now in use at the IAEA, and the related resin bead method for sample analysis is expected to be in use shortly. Also, the R&D on spent fuel bundle counters and on doorway monitors provided the experience necessary for today's systems being developed for the IAEA through several support programs. Finally, in our research on remote verification techniques, known by the acronyms RECOVER and TRANSEAVER, we are using current technology in international communications to open new vistas in cooperative verification for safeguards, physical security, and possibly additional arms control agreements in nonnuclear areas.

One example of the impact of our program is a series of contracts with Battelle Memorial Institute, through which ACDA has provided, since 1973, support to the IAEA in the area of systems analysis. Specifically, this effort has concentrated on certain key elements of IAEA safeguards, namely inspection planning and the evaluation of inspection activity and results. The statistical manuals and the computational procedures developed have been particularly well accepted because they are theoretically sound and at the same time recognize the practical needs of the inspector and the analyst. The output of this effort has also included formal documents such as the Safeguards Technical Manual, informally reported statistical methods and computer programs now in routine use by the IAEA, and direct assistance to the Safeguards Evaluation Section in establishing evaluation procedures for the effectiveness of inspection and verification activity.

Another example of the utility and the anticipatory nature of our research program is the series of four projects started late in fiscal year 1977 on safeguards implementation at heavy water production plants. The work proved to be particularly relevant and timely, since in October of 1981 an agreement entered into force between Argentina and the IAEA for the application of safeguards in relation to the heavy water production plant supplied by Switzerland.

Finally, the scope and effectiveness of our program in providing current information for the U.S. interagency community is illustrated by a study we initiated last year. With the entry into force in December 1980 of the U.S./IAEA safeguards agreement and the initiation of IAEA safeguards in selected U.S. facilities, the opportunity arose for the United States to gain firsthand experience in safeguards implementation. One of the facilities selected by the IAEA for safeguards is the low-enriched uranium fuel fabrication plant of the Exxon Nuclear Co. in Richland, Wash. In order to insure the availability to the U.S. Government of factual information on how safeguards are actually being implemented, ACDA contracted with Exxon to document in detail the IAEA safeguards inspection activities being carried out at the Exxon plant. The reports from this contract, which is still underway, are made available to other U.S. agencies concerned with safeguards.

Let me now turn to a project area for which ACDA has entered into a formal research agreement with the IAEA, and for which ACDA has expended a considerable fraction of its research resources for the last 4 years; namely, remote continual verification, or RECOVER for short. With the advances in communications technology and with the increased demands being placed upon the IAEA safeguards system, we feel that remote verification could play a substantial role in a range of safeguards situations as an adjunct to site verification.

The objective of the RECOVER program is the improvement of international safeguards through the remote monitoring of safeguards sensors and the secure transmission of safeguards data to central or local IAEA offices. For additional details on RECOVER, I want to mention that Mr. John Walsh wrote a very informative article in the July issue of Science, and that the General Accounting Office has underway an extensive review.

Very briefly I also want to mention the TRANSEAVER project, which combines RECOVER-type components with satellite and communications and navigational equipment, with penetration-resistant shipping containers, and with remotely monitorable sensors to provide continual monitoring of the location and integrity of nuclear material containers at sea.

Finally, for next year, fiscal year 1983, ACDA's budget submission to Congress includes $5,952,000 for external research. However, $4,800,000 of this amount are connected with the possibility of funding the program on reduced enrichment for research and test reactors in the budget of ACDA instead of DOE. This leaves $1,152,000 for the continuing research program in fiscal year 1983, with $310,000 of that allocated for safeguards. Although this is substantially less than the amount for fiscal year 1982, it is anticipated that the slow start in the current fiscal year and the consequent initiation of many of the projects just prior to fiscal year 1983 will permit us to bridge the gap until early fiscal year 1984. These factors enter into planning for ACDA's fiscal year 1984 budget, which is currently in preparation.

I do hope that my testimony today has served to provide information of interest to the subcommittee. I am, of course, ready to answer your questions and, as you may wish, provide additional written material for the record.

Thank you.

[The prepared statement of Dr. Menzel follows:]

STATEMENT OF JOERG H. MENZEL, PH.D.
CHIEF, NUCLEAR SAFEGUARDS AND TECHNOLOGY DIVISION
NUCLEAR AND WEAPONS CONTROL BUREAU
U.S. ARMS CONTROL AND DISARMAMENT AGENCY

before the

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, D.C.

on

"TECHNICAL ASPECTS OF NUCLEAR NON-PROLIFERATION: SAFEGUARDS"

August 3, 1982

It is an honor for me to appear before this Subcommittee today to discuss ACDA's external research program for international safeguards. In my oral presentation, I shall address the scope, effectiveness, and cost of our research program, the mechanisms to coordinate our program with those of other US agencies, other countries and the International Atomic Energy Agency (IAEA), and our plans for next year. With your permission, I shall provide for the record detailed information on individual projects and expenditures.

ACDA derives its mandate to conduct external research for international safeguards from Section 31 of the Arms Control and Disarmament Act of 1961, as amended, which states inter alia that "the Director is authorized and directed...to make arrangements (including contracts, agreements, and grants) for the conduct of research, development, and other studies in the field of arms control and disarmament by private or public institutions or persons". Further, it is specified that this research may include "the structure and operation of international control and other organizations useful for arms control and disarmament" and "the training of scientists, technicians, and other personnel for manning the control systems which may be created by international arms control and disarmament agreements".

Our external research program for international safeguards has been in existence since 1968. It may be of interest to note that ACDA was involved in developing and testing safeguards equipment for heavy water reactors as early as 1968, for reprocessing plants in 1970, and for enrichment plants in 1971.

ACDA's external research program is specifically designed to provide relevant information on international safeguards to US policy makers, to explore innovative safeguards approaches of potential use by the IAEA, and to support the US effort in strengthening IAEA safeguards. The program is characterized primarily by exploring the feasibility of new concepts and new technology, often with the close cooperation of one or more foreign governments and/or the IAEA. Significant effort has also been made in providing direct assistance to the IAEA in areas where ACDA staff have particular expertise, for example in developing methods for safeguards effectiveness evaluation.

The FY-1982 research program for international safeguards is planned for $836,000 or 41% of ACDA's total external research budget. The allocation for safeguards from our total research funds has remained fairly constant over the last six years taking into consideration the safeguards programs of other US agencies and the fact that fluctuations do result from variations in the start of specific projects. An overview of the relevant data for the period FY-76 through FY-82 is included in Table I of the written statement.

The scope of our safeguards research program is broad. Individual projects of the program fall within four major project areas, namely:

(1) Fuel Cycles and Facilities - The development of new or adjunct international safeguards approaches to nuclear fuel cycles and/or generic facilities.

(2) System Development - The development of requirements, procedures, and criteria for safeguards records/reports, inspections, information evaluation, and final conclusions.

(3) Instruments and Methods - The development of specific safeguards equipment and/or techniques for potential use by the IAEA.

(4) Remote Verification - The development of a technical capability for the timely, centralized monitoring of the status of surveillance devices deployed throughout the world.

The allocation of the safeguards funds among these four project areas varies from year-to-year depending upon priorities, the status of ongoing projects, the funding cycle and, of course, the nature of projects being sponsored by other US agencies. An overview of the project area allocations for FY-76 to FY-82 is shown in Table II of the written statement; the individual project titles and amounts for FY-82 are listed in Table III.

Within the broad scope of the program, the nature of individual projects is diverse. It ranges from development of fiber-optic seals to the design of features for heavy water production plants to facilitate the application of IAEA safeguards, from providing experts on a regular basis to the IAEA to assist in safeguards system development to demonstrating an instant-film remote-diagnostic surveillance system, from studying the feasibility of remote verification techniques to documenting the detailed negotiating history of IAEA safeguards documents. To illustrate this point, Tables IV and V of the written statement provide the individual project titles for FY-68 to 75 and FY-76 to 81, respectively; the latter also includes fiscal data.

ACDA's safeguards research program is carried out by a cadre of physical science officers dedicated to IAEA safeguards matters and thoroughly versed in nuclear technology and international safeguards. These professionals keep abreast of the latest developments in safeguards concepts and technology in the US and abroad, and they assure proper coordination of our research program with that of other US agencies and the IAEA.

This is accomplished through daily interaction with cognizant US agencies and individuals in the international safeguards community, through formal US interagency groups which meet on a regular basis, through participation in meetings of professional societies such as the Institute of Nuclear Materials Management, the American Nuclear Society, the European Safeguards Research and Development Association, and of various IAEA-sponsored technical groups and symposia, and through the framework of bilateral consultations with other governments. ACDA also furnishes the US expert for the IAEA Director General's twelve-member standing Advisory Group on Safeguards Implementation. The frequent interaction of our staff with the Department of Safeguards of the IAEA continues to serve as the focal point of our work. Finally, our staff has participated in or provided the leadership for multinational efforts such as the Tokai Advanced Safeguards Exercise, the International Working Group on Reprocessing Plant Safeguards, the Hexapartite Safeguards Project, and the RECOVER and TRANSEAVER programs.

We believe our safeguards research program to be effective. Naturally, as in any research program oriented toward innovative concepts and the use of new technologies, it is not always possible to predict the degree of utility or impact of a particular product. Sometimes it takes years for a new idea to bear fruit.

ACDA's pioneering work on fiber-optic seals provided the basis for recent R&D efforts sponsored by the Department of Energy and by the Juelich Nuclear Research Center in the Federal Republic of Germany. Our work on Isotopic Correlation Techniques for use at reprocessing plants has resulted in techniques now in use at the IAEA, and the related resin bead method for sample analysis is expected to be in use shortly. Also, the R&D on spent fuel bundle monitors and on doorway monitors provided the experience necessary for today's systems being developed for the IAEA through several support programs. And finally, in our research on remote verification techniques, known by the acronyms RECOVER and TRANSEAVER, we are using current technology in international communications to open new vistas in cooperative verification for safeguards, physical security, and possibly additional arms control agreements in non-nuclear areas.

One example of the impact of our program is a series of contracts with Battelle Memorial Institute, through which ACDA has provided since 1973 support to the IAEA in the area of systems analysis. Specifically, this effort has concentrated on certain key elements of IAEA safeguards, namely inspection planning and the evaluation of inspection activity and results, where improvements in IAEA capability is essential to strengthening safeguards implementation.

The US experts involved have been associated for many years with procedures for planning and evaluation of IAEA verification. Initially under the System Studies Program of the US Atomic Energy Commission and later under ACDA contracts, these individuals have been closely associated with the formulation of present IAEA inspection practices through acting as consultants, participating in working groups, formulating inspection principles, and developing safeguards effectiveness evaluation methods. The statistical manuals and computational procedures developed have been particularly well accepted because they are theoretically sound and at the same time recognize the practical needs of the inspector and analyst.

The output from this effort has also included formal documents such as the Safeguards Technical Manual, informally reported statistical methods and computer programs now in routine use by the IAEA, and direct assistance to the Safeguards Evaluation Section in establishing evaluation procedures for the effectiveness of inspection and verification activity. Part of this support is being incorporated in the US Program of Technical Assistance to IAEA Safeguards (POTAS).

Another example of the utility and the anticipatory nature of our research program is the series of four projects starting late in FY-77 on safeguards implementation at heavy water production plants. The work proved to be particularly relevant and timely since in October 1981 an agreement entered into force between Argentina and the IAEA for the application of safeguards in relation to the heavy water production plant supplied by Switzerland.

Finally, the scope and effectiveness of our program in providing current information for the US interagency community is illustrated by a study we initiated last year. The many US efforts over the years to improve IAEA safeguards have had to rely heavily upon inputs from the IAEA on their experiences in implementing safeguards in other countries, experiences which the US could not share because of the confidentiality of certain aspects of safeguards implementation. With the entry into force in December 1980 of the US/IAEA safeguards agreement and the initiation of IAEA safeguards in selected US facilities, the opportunity arose for the US to gain direct first-hand experience. One of the facilities selected by the IAEA for safeguards is the low enriched uranium fuel fabrication facility of the Exxon Nuclear Company in Richland, Washington. In order to ensure the availability to the US Government of factual information on how safeguards are being implemented, ACDA contracted with Exxon to document in detail the IAEA safeguards inspection activities being carried out in the Exxon plant. We have been most fortunate that the Exxon staff responsible for the documentation are very knowledgeable in IAEA safeguards and thus are able to analyze properly the inspection activities. The reports from this contract, which is still underway, are made available to other US agencies concerned with safeguards.

Let me turn now to a project area for which ACDA has expended a considerable fraction of its research resources for the last four years, namely remote continual verification or RECOVER for short. With the advances in communications technology and with the increased demands being placed upon the IAEA safeguards system, we feel that remote verification could play a substantial role in a range of safeguards situations as an adjunct to on-site verification. The objective of the RECOVER program is the improvement of international safeguards through the remote monitoring via the commercial international telephone network of safeguards sensors and the secure transmisison of safeguards data to central or local IAEA safeguards offices. The potential benefits are in terms of (a) improved effectiveness through the provision of more complete and more timely safeguards data contributing to more reliable and timely decisions by the IAEA and (b) increased efficiency in the use of IAEA inspector resources by reducing the effort needed for routine monitoring of safeguards sensors.

For additional details on RECOVER, I want to mention that Mr. John Walsh wrote a very informative article in the July issue of Science (Vol. 217, 16 July 1982) and that the General Accounting Office has underway an extensive review.

Recently, some confusion has been created by the fact that the acronym RECOVER is associated both with particular pieces of equipment to test their feasibility for potential IAEA safeguards use and with the general technology of remote verification which may have utility in monitoring nuclear shipments on the high seas and, possibly, some new arms control agreements. In coordination with the IAEA we have decided to use the term RECOVER to refer to the general technology, and the IAEA will continue test and evaluation with its own as yet unnamed remote verification system, with the assistance of the US and other members states.

As already mentioned, we are actively pursuing an application of RECOVER technology which touches upon international as well as national safeguards, namely the TRANSEAVER program which stands for Transportation-by-Sea Verification. The TRANSEAVER concept combines RECOVER-type components with satellite communications and navigational equipment (i.e., INMARSAT and NAVSAT), penetration resistant shipping containers, and remotely monitorable sensors to provide continual monitoring of the location and the integrity of nuclear material containers in a seaborne shipment. Should deviation from planned course or attempted tampering of the cargo occur, appropriate authorities would be alerted for appropriate action. We are joined in this $450,000 effort for FY-82 by NRC, DOD, State and DOE as well as appropriate offices in Japan and Australia.

For next year, FY-83, ACDA's budget submission to Congress includes $5,952,000 for external research. However, $4,800,000 of this amount are connected with the possibility of funding the program on Reduced Enrichment for Research and Test Reactors (RERTR) in the budget of ACDA instead of DOE. This leaves $1,152,000 for the continuing research program in FY-83, with $310,000 of that allocated for safeguards. Although this is substantially less than the amount for FY-82, it is anticipated that the slow start in the current fiscal year and the consequent initiation of many of the projects just prior to FY-83 will permit us to bridge the gap until early FY-84. These factors enter into the planning for ACDA's FY-84 budget which is currently in preparation.

I do hope that my testimony today has served to provide the information of interest to this Subcommittee. I am of course ready to answer your questions and, as you may wish, provide additional written material for the record. Thank you.

TABLE I

OVERVIEW OF ACDA'S EXTERNAL RESEARCH EXPENDITURES FOR FISCAL YEARS 1976 - 1982

Fiscal Year	Total Program ($)	For Non-Proliferation		For International Safeguards	
	$ (thousands)	% (thousands)	%	% (thousands)	%
1976	2,598	1,204	46	719	28
1977	2,238 (Obligated)	1,093	49	406	18
1978	3,636 "	2,621	72	1,887	52
1979	3,539 "	2,127	60	960	27
1980	3,795 "	2,513	66	1,377	36
1981	2,444 "	1,387	57	1,340	55
1982	2,040 (Planned)	890	44	836	41

TABLE II

ACDA'S EXTERNAL RESEARCH PROJECTS FOR INTERNATIONAL SAFEGUARDS
(Fiscal Years 1976 - 1982)

Project Area	FY 76	FY 77	FY 78	FY 79	FY 80	FY 81	FY 82 (Planned)
I. Fuel Cycles & Facilities	$130,820	116,000	578,495	10,000	100,000	189,500	91,000
II. System Development	117,885	None	213,184	233,822	403,616	192,000	155,000
III. Instruments & Methods	210,403	237,747	195,946	243,304	53,000	None	None
IV. Remote Verification	259,943	52,674	899,166	472,394	820,615	958,500	590,000
TOTAL	719,051	406,421	1,886,791	959,520	1,377,231	1,340,000	836,000
Total (Non-Proliferation)	1,203,911	1,092,712	2,620,783	2,126,718	2,512,915	1,387,000	890,000
Total (ACDA Research)	2,598,274	2,238,000	3,636,000	3,539,000	3,795,000	2,444,000	2,040,000

TABLE III

LIST OF ACDA'S SAFEGUARDS PROJECTS OBLIGATED OR PLANNED FOR FY-1982

I. Fuel Cycles and Facilities	
IAEA Safeguards Approach for an Aerodynamic Uranium Enrichment Plant (DOE/UCC)	$ 50,000
Reporting on IAEA Safeguards Implementation (EXXON)	$ 41,000
Subtotal	$ 91,000
II. Systems Development	
Assistance for IAEA Safeguards for Specific Improvements (INET)	$100,000
Detailed Negotiating History of IAEA Safeguards System Documents--Part 1: INFCIRC/153 (IEAL)	$ 25,000
Detailed Negotiating History of IAEA Safeguards System Documents--Part 2: INFCIRC/66 (IEAL)	$ 30,000
Subtotal	$155,000
III. Instruments and Methods	
No projects in this area.	
IV. Remote Verification	
RECOVER as an IAEA Safeguards Data Communications Network (Multiple Contracts)	$100,000
RECOVER Interface for Advanced TV Safeguards System (DOE/Sandia)	$190,000
Support for the International Test of TRANSEAVER (EI)	$300,000
Subtotal	$590,000
TOTAL	$836,000

TABLE IV

ACDA EXTERNAL RESEARCH PROJECTS FOR INTERNATIONAL SAFEGUARDS FOR FY 68-75

FY68

The Development of an Unattended Tamper-Indicating/Tamper-Resisting Instrumentation System for use in International Arms Control and Safeguards Inspections-PH	ST RA-63
Technical Support of Field Test FT-45 Tamper Resistant Data Link	WEC-155
Test Plan Field FT-45 Resistant Data Link	WEC-FO RA-51
The Development of an Unattended Tamper-Indicating/Tamper-Resisting Instrumentation system for use in International Arms Control and Safeguards Inspections	ST RA-52
Support of the ACDA Safeguards Research Program	ST RA-46

FY69

Development of a Prototype Neutron Flux Monitor for Unattended Safeguards Application	ST-175
Development of a Tamper-Resistant Safing System for International Safeguards and Arms Control Application	ST-174
Technical Support of Supplemental Analysis and Testing Under Field Test FT-45, Tamper Resistant Data Link	WEC-169
FT-62 Partial Support for an Evaluation of Minor Isotope Safeguards Techniques Mist in Reactor Fuel Reprocessing	WEC-FO RA-59

FY70

Applications to Minor Isotope Safeguards Techniques (MIST) to the Nuclear Fuel Cycle - Chemical Reprocessing safeguarding	WEC-188

TABLE IV cont'd

FY70

Application of Minor Isotope Safeguards Techniques (MIST) to the Nuclear Fuel Cycle-Nuclear Reactor Safeguarding	WEC-189
The Test, Evaluation and Improvement of a Prototype Neutron Flux Monitor for Unattended Safeguards Application	ST-191
The Development for Arms Control and International Safeguards Applications of an Advanced Prototype Identification System Employing Sceptron	ST-190
Development of Safeguards Instrumentation and Techniques	ST RA-91
FT-61 - Phase I - Component Testing of a Tamper-Resistant Instrumentation System for Reactor Safeguards	WEC-FO RA-88
Laboratory Techniques in Support of Arms Control Inspection Technology	ST RA-86
The Development and Testing of an Unattended Tamper-Resistant Instrumentation System for Arms Control and International Safeguards Uses	WEC-FO RA-80

FY71

Design and Fabrication of a Tamper-Resistant Liquid Level Monitor and Data Link for Chemical Reprocessing Plant Safeguards	ST-203
Applications of Minor Isotope Safeguards Techniques (MIST) to the Nuclear Cycle-Nuclear Materials Safeguarding	WEC-199
The Behavior of Minor Uranium Isotopes in the Streams of an Isotopic Separation Cascade	ST RA-108
Development of Safeguards Instrumentation and Techniques	ST RA-101
Analytical Support of Mist Minor Isotope Safeguards Techniques	ST RA-102
FT-61, Phase I, Component Testing of a Tamper-Resistant Instrumentation System for Reactor Safeguards	WEC-FO RA-96

TABLE IV Cont'd

FY71

The Design, Fabrication and Test of an Improved Neutron Flux Monitor for Unattended Safeguards Application	ST-209
Design and Fabrication of an Improved Tamper-Resistant Safing System and Secure Glass Container for International Safeguards and Arms Control Applications	ST-202
FT-71, Development and Demonstration of Tamper-Resistant Safeguards Instrumentation for a Chemical Reprocessing Plant	WEC-FO RA-116
The Design of a Pre-Production Identification System Employing Sceptron	ST-205

FY72

The Design, Fabrication and Test of a Spent Nuclear Fuel Monitor	ST-223
Design, Fabrication and Test of Unattended, Secure Safeguards Instrumentation for the Pickering Reactor	ST RA-144
Isotopic Measurements to Complement the Theoretical Study of the Safeguards Application of Minor Isotopic Data for Separation Cascades	ST RA-138
FT-71, Development and Demonstration of Tamper-Resistant Safeguards Instrumentation for a Chemical Reprocessing Plant	ST RA-131
The Fabrication, Calibration and Operation of Liquid Level Monitors for Safeguards use	ST-219
Development of Prototype Field Equipment to Process and Analyze Tapes for GE Neutron Flux Monitors	ST-217
Analytical Support of MIST (Minor Isotope Safeguards Techniques)	ST RA-132
Study of the Behavior of Minor Isotopes in Separation Cascades to Include Transient Calculations and Summary Presentations	ST RA-133
Applications of Minor Isotope Safeguards Techniques (MIST) to the Nuclear Fuel Cycle	WEC-214

TABLE IV Cont'd

FY72

Applications of Minor Isotope Safeguards Techniques (MIST) to the Nuclear Fuel Cycle	WEC-216
FT-71, Development and Demonstration of Tamper-Resistant Safeguards Instrumentation for a Chemical Reprocessing Plant	WEC-FO RA-127
FT-61 Tamper Resistant Instrumentation System for Reactor Safeguards	WEC-FO RA-126
FT-61, Tamper-Resistant Instrumentation System for Reactor Safeguards	WEC-FO RA-126

FY73

Fabrication of Fiber Optic Seals and Stressed-Glass Containers	ST-236
Support for US Participation in Joint US-Tripartite Test of Safeguards Application of Isotopic Data at the Almelo Centrifuge Plant	ST RA-163
Support of US Participation in Joint US-Tripartite Test of Surveillance Instrumentation for Enrichment Plant Safeguards	ST RA-164
The Field Test and Evaluation of the Time Domain Reflectometer (TDR) Liquid Level Monitor for Safeguards Use	ST-233
The Test and Evaluation of the Pickering Neutron Track-Etch Monitors	ST-232
Tamper Resistant Unattended Surveillance Instrumentation for Enrichment Plant Safeguards	ST RA-161
The Collection and Isotopic Analysis of Oak Ridge Gaseous Diffusion Plant Samples	ST RA-160
Technical Support for International Safeguards	ST-231
Analytical Support of MIST (Minor Isotope Safeguards Techniques)	ST RA-157
Development of Isotopic Safeguards Techniques	ST-227
Testing of Television Surveillance Equipment	ST-RA-156
Development of a Secure Safeguards Surveillance Camera	ST RA-152

TABLE IV Cont'd

FY74

Tamper-Resistant, Unattended Surveillance Instrumentation for Enrichment Plant Safeguards	NWT RA-172
Development and Evaluation of Fiber Optic Seals	NWT RA-171

FY75

Study on the Application of Charged Coupled Devices for Secure Safeguards Surveillance	NWT-267
Technological Studies in Support of International Safeguards	NWT-265
The Operational Test of the General Electric Track-Etch Neutron Monitors at the Pickering Nuclear Generating Station	NWT-262
Development of a Plastic Fiber Optic Safeguards Sealing System	NWT RA-178
Continuation of the Development and Application of Isotopic Safeguards Technology	NWT-260

TABLE V

ACDA'S EXTERNAL RESEARCH PROJECTS FOR INTERNATIONAL SAFEGUARDS FOR FY 76-81

PROJECT AREA: I. FUEL CYCLES AND FACILITIES

FY	Key-Word	Project Title	Contractor	ID	Amount
76	Reprocessing	Continuation of the Development and Application of Isotopic Safeguards Techniques to Chemical Reprocessing Plants	Battelle	AC6AC714	$100,802
76	Enrichment	Enrichment Plant Safeguards Study (Compl. of MIST III)	DOE/UCC	AC6AA705	30,000
77	Enrichment	Application and Evaluation of MIST in the International Inspection of Uranium Enrichment Plants	DOE/UCC	AC7NA309	106,000
77	Heavy Water	Heavy Water Accountability	DOE/BNL	AC7NA307	10,000
78	Heavy Water	The Design of Heavy Water Production Plants to Facilitate the Application of International Safeguards	CE/Lummus	AC8NC125	161,365
78	Enrichment	Study of the Application of International Safeguards at the Portsmouth Gas Centrifuge Enrichment Plant	DOE/UCC	AC8NA313	112,000
78	Enrichment	Study of the Application of International Safeguards at Advanced Isotope Separation Facilities	DOE/LASL	AC8NA314	150,000
78	Res. Reactors	Impact of Proliferation-Resistant Fuel Forms on International Safeguards	SSAI	AC8NC109A	9,973
78	Alternatives	An Evaluation of the International Safeguards for Alternative Nuclear Fuel Cycles	Teknekron	AC8NC119	145,157
79	University	Coordinated University Program for International Safeguards	L. Scheinmann	AC9ND409	10,000
80	Heavy Water	Safeguards Implementation at Heavy Water Production Plants	DOE/BNL	AC0NA318	100,000
81	Res. Reactors	Analysis of Research Reactor Proliferation Potential	DOE/ANL	AC1NA305	100,000
81	Heavy Water	Safeguards Implementation of Heavy Water Production Plants	DOE/BNL	AC0NA318A	50,000
81	Fuel Fab.	Documentation and Analysis of IAEA Safeguards Implementation	Exxon	AC1NC108	39,500

TABLE V Cont'd

ACDA'S EXTERNAL RESEARCH PROJECTS FOR INTERNATIONAL SAFEGUARDS FOR FY 76-81

PROJECT AREA: II. SYSTEM DEVELOPMENT

FY	Key Word	Project Title	Contractor	ID	Amount
76	IAEA Support	Tech. Studies in Support of International Safeguards	Battelle	AC6AC720	$117,885
78	IAEA Support	International Safeguards System Development	Battelle	AC8NC112	201,684
78	Spec. Project	Technical Support for the Verification of Core Reload at the TRR	DOE/LASL	AC8NA308	11,500
79	IAEA Support	IAEA Safeguards Evaluation Procedures	Battelle	AC8NC112A	59,646
79	Instr. & Meth.	Technical Evaluation of U.S. Supplied IAEA Safeguards Equipment	Ensco	AC9NX703	114,176
79	SSAC	IAEA Safeguards Diversion Detection and SSAC Analysis	DOE/LLL	AC9NA314	60,000
80	IAEA Support	Assistance to IAEA Development of the Safeguards System	Battelle	AC0NC106	221,962
80	Evaluation	IAEA Safeguards Evaluation Procedures, Phase II	DOE/LLL	AC9NA314A	132,000
80	Decision	IAEA Decision Structure	Decision Science Consortium	AC0NC110	49,654
81	Decision	Conference on Subjective Probability and Decisionmaking	Decision Science Consortium	AC0NC110A	5,000
81	IAEA Support	Assistance to IAEA Safeguards System Development	Battelle	AC1NC106	187,000

TABLE V Cont'd

ACDA'S EXTERNAL RESEARCH PROJECTS FOR INTERNATIONAL SAFEGUARDS FOR FY 76-81

PROJECT AREA: III. INSTRUMENTS AND METHODS

FY	Key-Word	Project Title	Contractor	ID	Amount
76	NDA	Feasibility Study of Passive Assay Tech. for Spent HTGR Fuel	IRT	AC6AC704	$ 30,403
76	Seal	Development of an Operational Fiber Optic Safeguards Sealing System	Army/HDL	AC6AA709	30,200
76	Surveillance	Enrichment Plant Safeguards Study and IAEA Safeguards Instrumentation	DOE/Sandia	AC6AA706	149,800
77	Seal	LASS - Linear Array Seal System	ARC	AC7NC109	48,974
77	Optical Syst.	Secure Transmission and Analysis of TV Surveillance Imagery	Fairchild	AC7NC102	188,773
78	Optical Syst.	Secure Transmission and Analysis of TV Surveillance Imagery	Fairchild	AC7NC102A	15,479
78	Seal	Further Development of Electronic Verification Methods for Safeguards Devices	ARC	AC8NC121	132,679
78	Seal	Further Development of an Advanced, Electronic Verifiable Seal	Fiber-Lock	AC8NC124	47,788
79	Seal	Fiber-Lock Level-Sensing Seal Modification	Fiber-Lock	AC8NC124A	3,003
79	Optical Syst.	Electronic Verification Capability for Existing IAEA Surveillance Devices	TRW	AC9NC111	87,083
79	Optical Syst.	Instant-Film Remote-Diagnostic Surveillance System	Aerodyne	AC9NC117	153,218
80	Optical Syst.	Special Application of a Polavision Surveillance System	Aerodyne	AC9NC117A	53,000

TABLE V Con't

ACDA'S EXTERNAL RESEARCH PROJECTS FOR INTERNATIONAL SAFEGUARDS FOR FY 76-81

PROJECT AREA: IV. REMOTE VERIFICATION

FY	Key-Word	Project Title	Contractor	ID	Amount
76	Feasibility	Feasibility and Design for Adaptation of PATTER for Monitoring Nuclear Materials	ARC	AC6AC705	$ 15,595
76	Feasibility	RECOVER - Remote Continual Verification	ARC	AC6AC734	244,348
77	Feasibility	Remote Continual Verification (RECOVER)	ARC	AC6AC734A	43,424
77	Feasibility	Display for Exhibit at IAEA General Conference	ARC	AC7ND415	9,250
78	Test & Demo.	Remote Verification of Surveillance/Containment Devices	ARC	AC6AC734A	24,446
78	Test & Demo.	Initial Implementation and Demonstration of the Remote Continual Verification (RECOVER) System	TRW	AC8NC120	874,721
79	Test & Demo.	Documentation and International Test of the RECOVER System	TRW	AC8NC120A	377,394
79	IAEA Support	IAEA Coordination on RECOVER	DOE/BNL	AC9ND403	5,000
79	IAEA Support	Support for IAEA/ACDA Research Agreement	DOE/BNL	AC9NA308	90,000
80	IAEA Support	Support for IAEA/ACDA Research Agreement	DOE/BNL	AC0NA303	75,000
80	Demo/Evaluation	Self-diagnostic Capability for IAEA Sensors/Int'l Demonstration for RECOVER/Continuing Support for Worldwide RECOVER System Operations	TRW	ACNC120A	745,615
81	IAEA Support	Support for IAEA/ACDA Research Agreement	DOE/BNL	AC0NA303A	90,000
81	Demo/Evaluation	Worldwide RECOVER	Multiple Contracts	Multiple Contracts	804,500
81	Feasibility	Development & Test of TRANSEAVER System	Energy Inc.	AC1NC110	64,000 (incl. $14K from NRC)

Mr. WOLPE [acting chairman]. Thank you very much, Dr. Menzel.

I would like to call upon now the gentleman from New Mexico.

Mr. LUJAN. Thank you very much, Mr. Chairman. I do have a number of questions.

Of all the statements, probably the one that concerns me the most Dr. Sessoms, is that you noted the IAEA Director General's statement of September 1981 that the agency could no longer give the requisite assurance that a diversion has not occurred in certain special cases. Could you elaborate on that a little more?

Dr. SESSOMS. Thank you, Congressman. Yes.

In his September statement, the Director General of the IAEA said that in the case of certain online refueled reactors, circumstances had changed to the point where the IAEA could no longer be sure that it knew all material flows through those reactors, so it could therefore not give independent verification that all material flows had in fact gone through IAEA observation channels.

Mr. LUJAN. Is that because they do not have accountability of the fuel or of the spent fuel, or because no one was there to verify it, or——

Dr. SESSOMS. The problem is that circumstances in the countries changed. In particular, the countries developed indigenous fuel fabrication capabilities that were not under safeguards, so the IAEA did not have, as it had before, information on precisely how much fuel was available to the country for use in that reactor. Therefore, they only knew what was coming out of the end by the records that the country gave them. It was not a closed loop; the loop was open.

The IAEA is now working very hard to solve the problem and in one instance it is satisfied that, at least in principle, the problem has been solved, and it is working very diligently at the moment to solve the other problems. There are two countries in question.

Mr. LUJAN. Are you saying they fabricate the fuel so they do not know how much went in there?

Dr. SESSOMS. The countries fabricate the fuel——

Mr. LUJAN. Don't they know by the number of rods that they have in there?

Dr. SESSOMS. The countries fabricate the fuel and the IAEA is not necessarily—and this is the IAEA's perspective—told everything that goes into the reactor, so they need an independent way of verifying everything that goes into the reactor. If the country fabricates the fuel, they can always not report some of the fuel if that fuel fabrication facility is not under safeguards, and that is the case.

Mr. LUJAN. Are you talking about major countries or some of the smaller countries?

Dr. SESSOMS. Some of the smaller countries.

Mr. LUJAN. The smaller countries, also?

Dr. SESSOMS. Yes.

Mr. LUJAN. That is not very good. That is cause for some concern.

As long as I have you here, it is my general impression—and I maybe should not have such definite ideas about it but it is my general impression—that international safeguards and matters of that kind are not of prime importance over at the State Department. You are a very capable individual but it seems to me that higher up there is not that dedication in the State Department.

It is a difficult question to ask you. Maybe I could ask you in private sometime or something like that. But more specific, besides yourself, what is the level of educational and professional background of the staff in safeguards at the State Department? Maybe that would be a better way to kind of ask the question.

Dr. SESSOMS. I was hoping you would give me an option of whether I should answer it here or in private. [Laughter.]

Mr. LUJAN. Well, other than yourself, do you have highly qualified people in that particular area, by education and background?

Dr. SESSOMS. I would say yes. Let me just say that the office that I am in, the Office of Nuclear Technology and Safeguards, spends about 75 percent of its time concerned with IAEA safeguards, and the Deputy Assistant Secretary who is my boss probably spends 40 percent of his time worrying about safeguards and maybe 85 percent of his time on nuclear matters in general. He also does nonnuclear energy technologies. In the Office of Nuclear Technology and Safeguards we have now a theoretical chemist, a Ph. D. theoretical chemist; we have people with years of experience in physical security and safeguards. The Deputy Assistant Secretary himself was over at the NRC, concerned with international safeguards matters and so on. The Under Secretary, Mr. Kennedy, who is the Governor to the IAEA, is himself very familiar with safeguards, having spent a good deal of time at the NRC and having been very involved in international matters, which are always safeguards—related in some way. Therefore, I think that the State Department has the expertise available to it to apply to some of these difficult problems and I think that people pay a lot of attention to the problems. In many instances you pay attention to where the problems are or at least to where the problems appear to be, and safeguards have gotten a lot of publicity lately and that serves very nicely to focus attention. We have been spending a lot of time, in fact, on safeguards and I think the attention is at high level.

Mr. LUJAN. Mr. Davis, on page 2 of your statement you make reference to some of the States not having open-arms acceptance of IAEA inspectors. Is that a tremendous problem or do you just find that maybe India would not accept somebody from Pakistan or something like that? Do you have great reluctance to inspectors from most or many member States?

Mr. DAVIS. Mr. Lujan, it is a problem that is basically hard to quantify. It is a problem that we hear about and since we do hear about it more than once we assume that, yes, there must be some reluctance on the part of some States to accept certain nationals but whether I could characterize it as one of the raging problems of IAEA, I am afraid I cannot qualify it in that particular sense.

I am fortunate to have, and I brought some with me, some experts from the NRC who perhaps would be able to assist me in giving a better quantification. I will ask James R. Shea, who is Director of the Office of International Programs, if he would care to perhaps elaborate on that.

Mr. SHEA. As Mr. Davis said, this is a problem that is hard to pin down.

Mr. LUJAN. Is it rumor or does it really happen?

Mr. SHEA. It is more than rumor. What you have, basically, as the central reason for the concern is a system within the IAEA which has a reason for existing, that allows countries to refuse to accept certain inspectors that are designated by the IAEA for assignment to their country to do the inspecting. They may turn them down because of certain political problems between the countries from which these nationals come and the country to be inspected, for example, or they just do not like them, or they find some——

Mr. LUJAN. Well, that is like when you go to court there: you can disqualify a judge but that does not mean you are not going to get another judge. Is that the situation that you find?

Mr. SHEA. Yes, that is right. Another inspector can then be designated, and if a country were to continue to do this, to turn down inspector after inspector even though there weren't credible reasons for their opposition, then that could in itself lead to suspicions about their motivations.

Mr. LUJAN. However, we do not have that situation, that latter situation?

Mr. SHEA. I am not sure that I can point to any cases of that sort but there are some cases where you have had some inspectors turned down where the result has been, I believe, to have inspectors come from a very narrow range of countries to the particular facilities to be inspected. That leads to, I think, a concern about whether you have a broad enough representation of countries in the inspection to provide the degree of confidence that you would like about inspections being done in a balanced and complete way.

Mr. WOLPE. I have a number of questions.

Mr. LUJAN. Interrupt me at any time you want to.

Mr. WOLPE. I thank the gentleman for yielding for just a couple of minutes. I would like to raise, first of all, a broader philosophical question with respect to the role of the IAEA safeguards. It was a subject that was raised by Chairman Bouquard in her opening statement and I would be interested in listening to reactions of members of the panel. In her opening statement, the Chairman attempted to differentiate rather sharply between domestic safeguards on the one hand and IAEA safeguards on the other, and argued that much of the criticism that had been leveled at IAEA safeguards was unwarranted and unjustified because it was not the purpose of the IAEA safeguards to prevent diversion; that was simply out of the scope of why they existed. I would be interested in the reaction of the panel. My understanding of IAEA safeguards was that indeed they were developed in order both to identify diversion of materials and secondly, by means of that identification, to prevent diversion. Would the State Department representative care to respond to that, and others as well?

Dr. SESSOMS. Thank you.

The IAEA objective, as was stated earlier, I think is to detect the diversion of materials or use of facilities for other than their stated peaceful purposes and to deter such diversion by the risk of early detection. The IAEA objective is that but it is an indirect deterrence. It is a political deterrence in a sense that——

Mr. Wolpe. In terms of the mission and goal, at least, is there any valid distinction between domestic safeguards on the one hand and IAEA safeguards on the other?

Dr. Sessoms. Yes, philosophically I think that they differ in kind because in international safeguards the IAEA is forced to confront a country, and they just have to go about confronting the country differently because the countries are also directors of the IAEA.

Mr. Wolpe. No, no, no. I understand the political mission. I am talking about the purpose. The purpose of domestic safeguards is identical, is it not, to the purpose of our IAEA safeguards? Would you agree, Mr. Caudle?

Mr. Caudle. I would like to discuss that point.

The domestic safeguards, from our point of view, are made up of two things: The first is consistent with the IAEA mission, and that is to detect diversion of nuclear materials. The other major objective that we have is to protect them also, so it——

Mr. Wolpe. Protect the what?

Mr. Caudle. Protect the nuclear materials, put in the fences, the guards, the guns, the gates; i.e., to make sure—a militaristic force, if you care to characterize it that way—to make certain that no one diverts the material, so you are protecting it. The IAEA does not have that mission.

Mr. Wolpe. However, again, the mission is essentially the same: to prevent diversion. I do not understand the distinction that is being made. You are saying the IAEA does not have within its safeguard arsenal the ability to create the military forces or police and security patrols that can protect materials, but is not the ultimate reason for safeguards simply to prevent diversion?

Mr. Caudle. The ultimate reason is the same, to prevent diversion. Domestically we carry it further and attempt to protect facilities against the theft or loss of SNM.

Mr. Wolpe. OK.

Mr. Caudle. It is the way that mission is carried out.

Mr. Wolpe. That is all I was trying to get at because it just seems to me that the distinction in terms of mission and purpose between domestic safeguards and IAEA safeguards is not really a valid one, and to the extent that we do not have the ability to detect diversion or to effectively prevent diversion, we have a problem.

The criticism leveled at the IAEA safeguards is not necessarily a criticism of ineptitude but it is a criticism of the system's inability to do the job. You just cited in your dialog with Mr. Lujan, Dr. Sessoms, one specific instance in which the IAEA has in fact had difficulty.

There is one other question I would like to ask, and it is my last question at this point: I wonder if members of the panel could compare and contrast the differences between safeguarding flow process technologies, such as reprocessing, and enrichment plants with once-through fuel cycle facilities which have easily counted fuel bundles? I would like you to compare the technical details, the relative costs, and the prospects for successfully safeguarding these two different kinds of technologies.

Who would like to go first?

Dr. **Sessoms**. I will respond first, Mr. Wolpe. I think you are hitting on one of the difficult points, just from a technological point of view. Flow process technologies like reprocessing facilities, or enrichment plants for that matter, are much more difficult to safeguard simply because they are flow processing. You have things continuously going on. They are not discrete, so it is rather difficult to go and count things. You do not count atoms. You count discrete pieces of equipment, pieces of fuel, whether it is fresh or spent, pieces of zirconium tubes and so on. You do not have that ability very easily with reprocessing plants or enrichment plants.

I think that the technologies exist at present to safeguard the small reprocessing plants that we have on-line now—for example, the plant at Tokai Mura, and the small plant that is being safeguarded in the FRG. I think the technology is adequate and available to do that. It is much more expensive, relatively speaking, to do that than it is to go and count fuel bundles at a light water reactor or in a spent fuel storage pond but it is a relative question because the absolute cost is small compared to the cost of the facility itself.

When you come to larger facilities—I alluded to this briefly in my statement—then we have to do some engineering. We have not a question of science or really a question of technology so much in the reprocessing plants as a question of engineering. You can do it pretty well but can you do it well enough for a cost that people will sit still for? We think so but we haven't done it yet because we haven't had to. Some of the experience we have indicates that it is certainly technically feasible. We have other indications that it is not all that expensive but "all that expensive" may be $10 million as opposed to $250,000. I think that Mr. Caudle can address more directly what it costs to safeguard a reprocessing plant. He has lots of experience doing that but in international safeguards I think that the question is really, How much is it going to cost you to do what you need to do, and is that cost reasonable? The answer is probably yes, but we do not know and it is going to take us a while to know.

Mr. **Wolpe**. Thank you, Dr. Sessoms. Mr. Caudle, would you care to respond?

Mr. **Caudle**. I cannot respond in an absolute manner regarding the costs. Normally when we work the system, we do both the functions that protect as well as prevent and detect, and so the dollars that I have in my mind are a combination of those two. However, I would think that the estimate that Dr. Sessoms has given of maybe $10 million for an average-size reprocessing plant might be a fair estimate. Again, from the technical point of view—and tomorrow the people that will appear will have more detailed technical knowledge on this subject—I think we have done a pretty good job over the last few years of looking at a reprocessing plant and what kinds of equipments and what kinds of configurations could you put together to have a system. Therefore, I think it is feasible to do it. I think the costs are large as compared to the costs of some other types of safeguards activities internationally. I think that there is also the point that you have to recognize, that if it is an operating plant and the operator's attitude is always to do first things first, that you could have considerable political difficulty or administrative difficulty in getting him to agree to incorporate that into his plan.

Mr. WOLPE. Thank you. Would anyone else care to make any observations?

Mr. DAVIS. With regard to maintaining the accountability of fuel, I would like to interject, of course, that that is largely dependent on having a history of that fuel. They are discrete items which can be counted but it is necessary to start out with the history of the fuel so that you track the fuel and also guard against substitution of the fuel. However, maintaining any discrete item accountability is much simpler technically than maintaining any, I would say, wet chemistry or reprocessing, chemical-type of accountability.

Mr. WOLPE. It is easier to maintain accountability in the once-through facilities where you have just a few bundles that you can count.

Mr. DAVIS. It is easier to maintain accountability of discrete items, which would be the fuel bundles never being dissolved and reprocessed, than it would be to maintain accountability of a reprocessing plant.

Mr. WOLPE. OK. I misunderstood you. That is what I thought you were saying. Thank you. Dr. Menzel?

Dr. MENZEL. You have part of the answer in your question, namely, it is indeed easier to count items than to count bulk materials. In your characterization, however, of once-through, one needs to remember, for example, that an enrichment plant is a bulk facility but to a large extent it is an item facility; namely UF-6 cylinders. In terms of the next step in the nuclear fuel cycle, in a fuel fabrication plant, it is items of cans of oxide, for instance, and then in the intermediate process it is powder and pellets; then at the end you go into discrete items; namely, fuel assemblies. So by the time you end up in the reactor you have already had two facilities involving mixtures of bulk and item accountability, if you want. At a light water reactor, of course, it is item accountability. At a heavy water reactor, it is currently not item accountability. The next step, reprocessing plants, the entry is item accountability in the spent fuel pond; and it retains item accountability until the chopping and dissolution of the fuel; at the end, depending on what kind of reprocessing plant it is, again you convert the bulk material to items—bottles or cans of oxide—so it is really a mixture. But whenever bulk material exists, as such, it is indeed more difficult to account for the nuclear material.

Mr. WOLPE. Just a follow-on question: Are you saying there are difficulties accounting for all material at our own weapons manufacturing facilities here in this country? Is that correct? Mr. Caudle?

Mr. CAUDLE. The difficulty is similar to what Dr. Menzel discussed. He left out one thing that I would like to highlight and that is, during the time that you are in a reprocessing facility with fixtures that contain a multitude of tanks, perhaps miles of piping—some are horizontal, some are vertical, some are leaning—the consistency of the isotopic content from one part of the pipe to another might differ. Part of that material might plate itself out on the pipes, so all that comes in when compared to all that comes out the other end after it has been reprocessed, there is hold-up within the plant. To specifically identify and say that I absolutely certify to you to plus or minus zero percent that I know that there is so much in this part of the pipe, and so much in this tank, we cannot do that. Therefore, I do not want you to use the word "missing" or any kind of word like that. It is just that that is material that has been held up and is called an inventory difference because it is the difference between what went in and what came out. Does that make sense to you?

Mr. WOLPE. It does, but my recollection is that in a GAO report in 1980 there was at least one reference made to one plant, one operation, in which there were quantities of relatively substantial magnitude missing, more than would be accounted for in some kind of internal "diversion," if you will, for lack of a better word.

Mr. CAUDLE. I am not familiar with that particular report, but let me say that the magnitude—and again it depends on what is an important magnitude to you but we look at category I which would be 2 kilograms of plutonium or 5 kilograms of the enriched uranium——

Mr. WOLPE. OK. Thank you.

Mr. CAUDLE. If you look at those, when you consider the quantities of materials that are processed through some of the facilities, that is not a large amount.

Mr. WOLPE. Thank you very much. Mr. Lujan, would you like to continue?

Mr. LUJAN. Thank you, Mr. Chairman. Let's continue on the question of inspectors at sites. Dr. Menzel, I assume you were talking about some kind of remote instrumentation to monitor whatever is going on. Are you suggesting that some time in the future, or maybe even now, we will be able to have instrumentation in a plant that could be hooked to some computer, maybe through a satellite, and somebody can sit over at IAEA and monitor whether there is any diversion or not? Is that possible?

Dr. MENZEL. No, I am not prepared to look that far into the future.

Mr. LUJAN. Well, you did mention RECOVER and TRANSEAVER and I assume that you were saying that is the direction we are moving in.

Dr. MENZEL. Right. Yes, Mr. Lujan, that is the direction, where some of the technology can assist onsite verification. Technology can provide, either on a plant level such as a reprocessing plant where various data points can be led to a central point or on a world-wide level where the instrumentation installed by the IAEA at various facilities in a country can report its status, important safeguards information. For example, the status safeguards instruments such as surveillance cameras. Are they operating? Are they not operating? Is the battery low or not?—that kind of information fed to a central point in the country or to the IAEA in Vienna can be of use in making safeguards more effective in terms of timeliness, of knowing the status of its instrumentation, and also in terms of efficiency. When they go to the facility they may be able to take spare parts with them because they know ahead of time what the problem is. Therefore, these are the range of applications which we feel are worthwhile exploring in our program on remote verification. I think in 5, 10 years that this will play a significant role.

Mr. LUJAN. I am sorry.

Dr. MENZEL. That's OK.

Mr. LUJAN. What I am trying to do in my questions are two things: find out as much as I can, while we are waiting for Mrs. Bouquard to come back. She had to go testify. I do not want to hog all the time, so anybody that has any particular questions as we go along, why, do not hesitate to interrupt.

I was interested in this IAEA experiment at Richland with Exxon. In the whole experiment, in the whole project, are they trying to fool the IAEA as part of the experiment or are they just trying to see how well it works?

Dr. MENZEL. They are certainly not trying to fool the IAEA, and in that respect it is not an experiment.

Mr. LUJAN. I do not mean fool them in the sense of making fools out of them but in terms of research—"Let's try this and see if we can get away with it, to see how we improve IAEA inspection or surveillance."

Dr. MENZEL. No, it is not an experiment in that sense. It is the documentation and assessment of the actual safeguards approach at the Exxon plant in Richland. So the Exxon staff—and there are several who are very experienced in international safeguards—document what the IAEA does, the sampling plan, the kind of measures that the IAEA employs, the kind of nondestructive assay equipment, the kind of statistical comparison tests. They document those things and then they assess how effective the particular inspection strategy is at that facility. Therefore, it is not an adversary kind of documentation or project.

Mr. LUJAN. Would it be good to inject that in terms of research?

Dr. MENZEL. I do not believe that in this case, and with the actual implementation of IAEA safeguards under the U.S. offer, it would be good to inject the kind of tests that you are suggesting.

Mr. LUJAN. Well, if my memory serves me correctly in the safeguards area, we do that at Barnwell. You know, try to get people get out with material.

Dr. MENZEL. In the domestic safeguards area, as I understand, the Department of Energy does do the kind of "black-hatting" that you refer to. That is correct, but one must remember in this case we are not talking about an experiment. We are talking about the actual implementation of safeguards under the U.S./IAEA safeguards agreement. It is a legal obligation that we have. It is not an experiment and what I mentioned in the ACDA research program—and I apologize if I did not make that clear enough—is that the contract we have with Exxon is for the documentation and assessment of the inspection activities, nothing more than that.

Mr. LUJAN. Can you tell us if IAEA is doing a good job?

Dr. MENZEL. Yes, they are, at Exxon.

Mr. LUJAN. No, that is not what I asked you.

Dr. MENZEL. I see.

Mr. LUJAN. The purpose of the agreement between Exxon and IAEA is to determine if IAEA is doing a good job. Would Exxon then come back and tell the Arms Control and Disarmament Agency that IAEA did a good job or they did not do a good job or whatever? Is that the purpose? I am trying to figure out why you are doing it.

Dr. MENZEL. That is the purpose. The purpose is to document in great detail the technical aspects of safeguards as implemented at Exxon. It is an assessment of IAEA activities that they are conducting. In the past, prior to the implementation of IAEA safeguards in the United States we did not have firsthand experience of the implementation of IAEA safeguards. We had information from the IAEA through the regular channels of the safeguards implementation report and other reports but we did not—if I may—we did not experience safeguards as placed upon us. The U.S. offer or the implementation of the U.S. offer indeed now provides us with that firsthand experience. We, the United States at certain facilities, are being inspected and with the same objectives, with the same approach as would be used in another country for the same kind of facility. So it is the lessons we can learn from that experience. It is a window, if you wish, into the IAEA and through that we can see: Should we adjust our research program or our support program for the IAEA? Should we discuss certain shortcomings, if there are any, with the IAEA? We assume that the same shortcomings would be the case in another country at a similar facility.

Mr. LUJAN. One final question, I guess for Mr. Caudle. I noticed in a lot of our programs that we move ahead with our own research, and many times we disregard what other nations are doing in the same program that we have, for example, gasification projects, maybe even breeder technology, waste technology, nuclear waste technology. How much interplay is there between us and other nations as to their methods and ours? How much technology exchange?

Mr. CAUDLE. There is a considerable amount of interplay. First, let me start with something that is required by the Nuclear Nonproliferation Act. We have specific courses that are for the people overseas, the international group. One comes to Sandia for workshops in what are called the physical protection areas—guns, gates, guards, sensors, those kinds of things—and then we have the same requirement for a course in nuclear materials control and accountability which is performed at Los Alamos. The people come to this country to learn. They actually go through various periods of instruction, see the equipment, and become familiar with the equipment that we have. Additionally, we have bilateral agreements with various countries which I mentioned, like Germany, like the United Kingdom, Australia, and Japan, in which we not only have meetings back and forth to discuss these—these will be certain specific meetings for relatively short period of time, a few days, perhaps—but we also exchange scientists for longer periods of time. Additionally, there is something just like the Institute of Nuclear Materials Management which met here in Washington about 3 weeks ago. That attracts an international community that also attends. Our people from the Department of Energy and the other persons represented here have their technical people there that present papers. There are displays of the equipment, with people there that are capable of explaining what is in the display, what it is and how to use it. Therefore, I feel that there is a very good exchange internationally and domestically on our technology.

Mr. LUJAN. Thank you. Thank you, Madam Chairman.

Mrs. BOUQUARD. Thank you very much. Mr. Hollenbeck?

Mr. HOLLENBECK. Yes. Thank you, Madam Chairman. Along those same lines, how successful have we been in the direct transfer of safeguards technology to other countries without using IAEA as a middleman. I believe you can give us some examples concerning Japan and Canada.

Mr. CAUDLE. I think that I would say that we have been very successful there also. The primary way of doing it is the scientist-to-scientist exchange. We cooperate fully with anyone that asks, respecting anything that might be of a classified nature that we are doing, but it is my summary that it is good, it is complete, and the transfer goes both ways. We have learned things from them. Normally we always think that we know it all and give it away but in the area of safeguards and security we find that it is a good two-way street.

Mr. HOLLENBECK. What do you mean by the term "a nuclear-free zone," Dr. Menzel?

Dr. MENZEL. Did I mention that? [Laughter.]

Mr. MENZEL. What is normally meant is a nuclear weapons-free zone such as in Latin America in connection with the treaty of Tlatelolco.

Mr. HOLLENBECK. Thank you, Madam Chairman.

Mrs. BOUQUARD. Thank you very much, Mr. Hollenbeck. I want to apologize to you distinguished gentlemen for leaving. I had to testify before another committee on a subject that is very dear to your hearts, nuclear proliferation, so I do apologize for having to be absent in part of your testimony, Dr. Menzel.

Mr. Caudle, on the bottom of page 5 of your testimony, you stated that the largest of the DOE safeguard efforts is the development of safeguard concepts for application at the gas centrifuge plant [GCEP] at Portsmouth, Ohio. How much is really being expended in this effort? What is the scope of work being carried out at Portsmouth?

Mr. CAUDLE. Under the offer that was made, the voluntary offer, we have designated the gas centrifuge enrichment plant at [GCEP] Portsmouth as one of the facilities in this country that will come under IAEA safeguards.

Now in the international effort that I have, one of the things that I identify that way is the GCEP effort. The reason for doing the effort is that we want to thoroughly understand ourselves how that plant can be safeguarded without an incremental risk of losing technology to an inspector who might come in. The gaseous centrifuge technology is sensitive and we want to keep it, so we have an effort working not only from a design point of view but putting it into the plant and testing it, various strategies that might be used that would satisfy the IAEA and ourselves that it is a good safeguards strategy, that if anyone tried to misuse that plant to produce highly enriched uranium rather than low-enriched uranium, that you would be able to detect that action, and again weighing that versus the risk of losing the technology of plant design. Therefore, we want to satisfy ourselves; that is No. 1.

Mrs. BOUQUARD. Are you working in the area of plant design or in technical information or training of personnel?

Mr. CAUDLE. It is primarily at this stage of the game identifying the kinds of equipments and the kinds of sensors and the techniques for using those by inspectors who came into that plant, such that they could make themselves certain that we have not used it incorrectly, that is, to produce highly enriched uranium, so we are developing——

Mrs. BOUQUARD. You are not working in the plant design?

Mr. CAUDLE. We are not changing the design of the plant in the normal operating mode. What we are looking at are things like neutron detectors or gamma detectors, and how would you mount them or how would you use them in the plant to see that it had not been misused. That is to satisfy ourselves. There is also another very important objective, and that is, that as we satisfy ourselves that it can be done and can be done properly and without the risk of the loss of technology, we are working with the others in the world who are going into the same kinds of activities—the Japanese in particular, and the Germans—to indicate to them that there is a way that you can safeguard a gaseous centrifuge enrichment plant without divulging the sensitive technology which each country is trying to protect, so it is twofold.

Mrs. BOUQUARD. Are you measuring materials?

Mr. CAUDLE. Pardon?

Mrs. BOUQUARD. Are you measuring materials in this process, or evaluating techniques?

Mr. CAUDLE. Right now we are evaluating techniques. The plant comes online, I believe, in fiscal year 1984, and right now we are evaluating the techniques which do encompass the measurement of material to see whether it is low-enriched uranium or highly enriched uranium, to be able to verify that the plant is being used solely for the production of low-enriched uranium.

Mrs. BOUQUARD. Mr. Caudle, do you conduct joint R&D efforts with the Department of Defense? I know that certainly the weapons program is under your jurisdiction, but what type of joint projects do you carry out with the Department of Defense?

Mr. CAUDLE. I want to limit myself, if I may, to safeguards and security today on that. We work very closely with them as we look at protecting the storage sites for nuclear weapons, both within the continental United States and overseas. We are looking at, again, the things that I have talked about: guards, guns, gates, sensors, barriers, and other things which will give us an ability to better protect those weapons in particular that are stored overseas.

Mrs. BOUQUARD. I do want you to go into some detail on the Nuclear Materials Management and Safeguards System, if you would. What does it do and what are its capabilities?

Mr. CAUDLE. That is the Nuclear Materials Management and Safeguards System?

Mrs. BOUQUARD. Yes, sir.

Mr. CAUDLE. We normally call it NMMSS. That is the system that is charged with the responsibility to monitor all nuclear material of U.S. origin, regardless of its location, either in the United States or overseas where we have loaned it or sold it. Additionally, it is charged with the responsibility to monitor the location of foreign nuclear material that comes into the United States, and we have the agreements with the countries that we will monitor that and know where it is. Therefore, it has the responsibility to account for those types of nuclear materials.

Mrs. BOUQUARD. Where do you think there needs to be more refinement in this area? In personnel or in measurements?

Mr. CAUDLE. Speaking in general to safeguards, domestically, I think from a personnel point of view, we are in good shape. From a systems point of view, looking at the components that go into making a total system, I think we need to pursue that more. We are doing that, in fact. I think we have a good level of effort on that and it is just a matter of time that we will have a good system. If you speak to the IAEA, I think it is both. The personnel need to be trained better. I think, as Dr. Menzel said, we need more inspectors than at the present time. The equipments need to be better oriented towards the user. We should carry out field testing and encourage acceptance by the inspectors that they want to use that equipment, and instruct them how to use it, and use it accurately, and insure that there is someone there who can maintain that equipment, and assure that there is enough equipment available to do all of the jobs.

Mrs. BOUQUARD. Thank you very much.

Mr. CAUDLE. Thank you.

Mrs. BOUQUARD. Mr. Davis, you noted that the NRC had sponsored a technical objectives study on goals of IAEA safeguards and associated research implications. Were you referring to the May 1981 study that was prepared for NRC by Pacific Northwest Laboratory, Battelle, Exxon Nuclear Co., and Science Applications, Inc., entitled, "Implications of IAEA Technical Objectives"?

Mr. DAVIS. Madam Chairman, let me turn to my technical assistant here, Mr. Bob Burnett, who is our "Mr. Safeguards" in our agency.

Mrs. BOUQUARD. Very fine. We look forward to hearing from you.

Mr. BURNETT. Bob Burnett here. That is a follow-on of a previous effort that I am sure the Hill has seen a report on, which had illuminated that additional manpower and equipment would be necessary to fully satisfy the objectives of the IAEA. If you remember that report, it said that an order of magnitude of more inspectors would be necessary. Now the IAEA feels that less would be necessary, so we are further refining that estimate and looking at what could be accomplished with the manpower that they have and within the projected future.

Mrs. BOUQUARD. In other words, the thrust of their objectives exceed their pocketbook. Is that correct?

Mr. BURNETT. Yes, ma'am. Their objectives right now are goals. They do not have the capability to satisfy those goals right now.

Mrs. BOUQUARD. Has this report been updated since the 1981 results? Are there any changes? Does NRC agree with these conclusions?

Mr. BURNETT. No, Madam Chairman, it has not been updated yet and that is what this follow-on effort is to do.

Mrs. BOUQUARD. Fine. Mr. Burnett, you may also want to answer this question: The July 15 issue of the Wall Street Journal carried an interesting article entitled, "The Administration's Risky Plutonium Policy," written by Commissioner Gilinsky. One of the interesting aspects of this article is that it did not mention President Carter. From this one would assume just by reading the article that President Reagan succeeded President Ford. [Laughter.]

In any event, he refers to a March 2, 1982 letter to congressional oversight committees from the NRC which stated that because plutonium "can be transformed readily into weapons, we cannot count reliably on inspection alone to provide warning of diversion of HEU [highly enriched uranium] and separated plutonium in time to prevent weapons assembly if the necessary preparatory work has been done." Does the NRC still stand behind this statement?

Mr. **BURNETT**. Yes, Madam Chairman——

Mrs. **BOUQUARD**. We cannot rely on inspection alone for enough of a warning?

Mr. **BURNETT**. Well, you have to remember that the accuracy of the NDA equipment, the nondestructive analysis equipment, is limited and generally it is in the area of 1 percent or slightly above that. At bulk processing facilities where you have a lot of material going through, that 1 percent still leaves a large uncertainty, so it takes more than just inspection. It takes the dedication of the country involved. Therefore, yes, I guess the NRC still feels that way.

Mrs. **BOUQUARD**. Does the NRC doubt the adequacy of all IAEA safeguards, or only for some facilities?

Mr. **BURNETT**. Only at some facilities, ma'am.

Mrs. **BOUQUARD**. What technical improvements would be needed at such facilities for the NRC to change its mind?

Mr. **BURNETT**. We are working with the executive branch, and the witnesses here before you today alluded to those groups, the POTAS studies, that we are participating with to increase the effectiveness of NDA and inspection techniques and more data available to the United States.

Mrs. **BOUQUARD**. I think the NRC basically carries out its safeguards responsibility by focusing more on performance standards. Is that correct? Does it not emphasize the capability of the licensee?

Mr. **BURNETT**. Well, the Commission itself looks at both. From a safeguards perspective it is performance oriented but in the commission of their duties they take into account broader issues than just safeguards.

Mrs. **BOUQUARD**. Well, how do you and the DOE differ in your responsibility in setting up your criteria?

Mr. **BURNETT**. Basically, I do not really think we differ that much with the DOE. Our Commission, of course, is composed of five gentlemen and they are not of like minds on this issue. I think that has to be said. Consequently we do look at a broader spectrum.

Mrs. **BOUQUARD**. Thank you very much.

Dr. Sessoms, do you feel that present safeguards R&D covers all of the gaps in the present systems that would have to be filled if plutonium is to have a commercial future?

Dr. **SESSOMS**. I do not know that I would strongly couple the safeguards R&D to the commercial future of plutonium, although they are somewhat connected, Madam Chairman. I think that the commercial future of plutonium is going to be based primarily on economics and on the success of development of the technology.

I think that the R&D that we are doing now will be able to keep pace with the development of plutonium-using reactors and of reprocessing plants if present projections are correct. I think that if things blossom, in the sense that technology developed very quickly and became very economical in the near term, then we would have to expend significantly greater resources, but our projections indicate that what we are doing is about right to keep pace with the technology. The economics, I think, will drive whether plutonium really has a commercial future or not, not safeguards.

Mrs. BOUQUARD. You think that economic concerns will preceed the safeguards standards in the public acceptance of plutonium into the world marketplace?

Dr. SESSOMS. No, I think what I am saying is that whether plutonium enters in the world marketplace at all will be dependent on economics, and I think that the way things seem to be going, the present safeguards research and development activities will be able to keep pace with the introduction of plutonium because economics is, in fact, the thing that limits its introduction in the commercial sector.

For example, I do not think that we have to be concerned in general with making very inexpensive safeguards systems for large reprocessing plants for the next 10 or 15 years. I do not think there will be any because there is no commercial justification for it. I think we can concentrate on few facilities and put a lot of energy and money into those facilities to make sure that as they come on they are, in fact, adequately safeguarded.

Mrs. BOUQUARD. Thank you. Dr. Sessoms, you note that software was put into routine use to improve timely analysis and reporting of IAEA inspection results. Whose responsibility is it to decide what the improvements are, who should develop them, and who should fund their regular use?

Dr. SESSOMS. The IAEA has the responsibility for that and the system works, I think, as follows: The IAEA identifies inadequacies or problems with its own system and requests key member-States, those that have support programs, to help them solve the particular problem. Therefore, for example, we get from the IAEA requests for 50 or 60 projects a year that they find are of particular importance and we do what we can to help solve the problems in as short a time frame as possible. They do this with other support programs as well but it is the IAEA's responsibility.

We help them out, of course. There are all sorts of consultants' meetings, technical meetings in Vienna that the United States and the other member-States participate in that help the IAEA identify its shortcomings and propose solutions, and we then try to give them the help required to find those solutions quickly.

Mrs. BOUQUARD. Well, you mentioned a number of projects and equipment development work in your testimony. Are most of these projects in support of light water reactors, or are they anticipating and laying the groundwork for commercial plutonium?

Dr. SESSOMS. I think that not very many of the projects are in support of light water reactors. I think we feel fairly comfortable that we can safeguard light water reactors. The agency does a pretty good job, and I think that the research and development effort in that regard is primarily aimed at improving the inspector actions to make sure the inspector really does the list of things you give him to do, and you have a system for checking up on him to make sure he did it. That is where we focus on light water reactors.

The nondestructive assay equipment, the systems studies are focused on reprocessing plants, on mixed-oxide fuel fabrication plants, on breeder reactors, on——

Mrs. **Bouquard.** On the design?

Dr. **Sessoms.** Yes; on the design of the facilities as well. NRC has been doing quite a bit of work through its own funds on designing facilities to facilitiate safeguards. ACDA has done it as well. We have done some through the support program. Therefore, the focus has really been on strategic materials and that is becoming a greater focus now.

Mrs. **Bouquard.** You talked about the Tokai Mura reprocessing plant and the work that was done. Will the results of this work be available to the IAEA and others, or will it be tightly controlled? Also, you did not mention safeguard work at Barnwell. Is this not considered relevant?

Dr. **Sessoms.** Oh, on the contrary. Tokai Mura was a joint exercise between the United States, France, Japan, and the IAEA, and the results of the Tokai exercise have been published by the IAEA. Everything is available to the general public now. In fact, the Japanese are in the process of sharing that technology on a bilateral basis with the West Germans so that safeguards can be facilitated in any future German reprocessing plant.

The Barnwell exercise is sort of a quantitative change, and we are in support of safeguards exercises at Barnwell that can be used to promote and develop safeguards technologies for facilities of that kind. We have had discussions with the AGNS people about some proposed exercises and we think those exercises would be in the best interests of international safeguards and we support them in that regard, in collaboration, for example, with Japan, with Germany, or with whoever else who would have a particular interest and benefit derived from that exercise.

Mrs. **Bouquard.** Was TASTEX an advanced safeguard testing exercise?

Dr. **Sessoms.** The TASTEX was the Tokai advanced safeguards technology exercise, and we concluded it about a year ago. Barnwell is a much more complicated beast because it is so much bigger than the AGNS people have developed, I think. It is a very clever safeguards approach and I think we in State are anxious to see it further developed and tested.

Mrs. **Bouquard.** Thank you very much, Dr. Sessoms.

Dr. Menzel, you do not mention ACDA work plans for fiscal year 1983, when funds will be tighter. What work is going on in this year's budget will have to be dropped or cut back?

Dr. **Menzel.** Like I said in my statement, because of the budget cycle and because of the cycle of negotiations that ACDA is responsible for, we indeed had a slow start in our research program and most of our projects—I would say about 80 percent of our projects—are in fact being initiated in the last 3 months of this fiscal year. We anticipate that we can carry through if we can look at the start of fiscal year 1984 with reasonable certainty as budget matters go. We are definitely in a tightened budget situation and we are adjusting our program to that tightened budget.

Mrs. **Bouquard**. When you were talking about ACDA's four areas of interest, you did not indicate which fuel cycles you had in mind. Are you leaning more toward the light water cycles or heavy water, particularly CANDU reactors? Also, what are you doing on breeder fuel cycles?

Dr. **Menzel**. The project area of fuel cycles and facilities is just indicative of an area of research. As I noted in the statement, we do adjust our research to reflect and not to duplicate, in fact, what others are doing. In the area of fuel cycle facilities, for instance, we do not favor any one cycle. We look at what gaps there are in the research being performed for whatever fuel cycle facility it may be. A good example is safeguards of a heavy water production plant. The facilities in the United States are not part of the U.S. offer. They are DOE defense program facilities, yet we knew that the IAEA would be faced with having to safeguard such a facility in the not too distant future, namely the facility being sold by Switzerland to Argentina. Prior to the negotiation of the facility attachment and even prior to the negotiation of the safeguards agreement covering that facility, we initiated work with a company called Combustion Engineering/Lummus, a commercial company thoroughly familiar with the design and operation of heavy water production plants. That is one example. If we see other areas in safeguards approaches for certain nuclear facilities that are not being addressed by either the POTAS program or the other agencies or abroad we encourage others to do so or do the work ourselves. As an example from abroad, for instance, the United Kingdom has a substantial portion of its IAEA support program in the breeder area. At Dounreay and at Windscale there are fuel fabrication and reprocessing plants under safeguards so that the whole breeder fuel cycle is part of the United Kingdom's support program for the IAEA. Therefore, we adjust our——

Mrs. **Bouquard**. You are filling in the gaps that you see in other programs?

Dr. **Menzel**. Yes. We are a small agency with a small program.

Mrs. **Bouquard**. Dr. Menzel, I noticed that table II for ACDA's budget did not show any funds for instruments and methods and almost a halving of funds for R&D. What have you had to cut out to accommodate these reductions?

Dr. **Menzel**. Well, it is less a matter of cutting out as avoiding duplication. In the past we had sponsored work on TV surveillance systems. We had sponsored work on neutron measurements. With the POTAS program and the work of the Department of Energy, we have felt that any continued work in this area would be duplicative. We are following closely the work of others, we are a participant in the various committees that Mr. Caudle and others have referred to and we are confident that the instrumentation being developed, both in the containment and surveillance area and in the nondestructive area, are the kind of instruments that will strengthen international safeguards, so we wanted to avoid any duplication. One area where we still do hardware development is in remote verification. Sometimes when you get into the sensor part, namely, what is it that provides you the signal that the IAEA is particularly interested in, it is that area that is on the borderline of going into the project area of instruments and methods and the project area of remote verification; so we have emphasized in recent years the remote verification.

Mrs. **Bouquard**. I was getting ready to ask you about remote verification. Could some of this technology be used to give IAEA inspectors a secure, independent channel of personal communications with Agency headquarters without using our national telecommunications system?

Dr. **Menzel**. Yes. As a matter of fact, the most recent development in that area is precisely the secure communications of data, of inspectors' data from a nuclear facility to the IAEA headquarters. To be more specific, the inspector fills out a 2-page inspection sheet, and it is this summary of the inspection result where we have developed the capability, and have demonstrated that capability to the IAEA, to transmit that information in a secure manner. We have demonstrated it with the cooperation of the Government of Japan, for instance.

Mrs. **Bouquard**. Thank you. I was very interested in your answer.

Dr. **Menzel**. Thank you.

Mrs. **Bouquard**. I am going to close by asking you gentlemen if you care to comment on what you perceive as prominent area where IAEA safeguards needs improvement? What area would you suggest, Mr. Caudle? Techniques, materials, inspectors?

Mr. **Caudle**. Inspector manning, inspector training, conversion of equipment from the research and development stage to the point that it is implemented; that is, it is there for the inspector to use, that they be able to maintain it, and that they have it in sufficient quantity.

Mrs. **Bouquard**. Very good.

Mr. **Davis**. I would have to echo those comments. I believe primarily some substantial increases in inspection personnel and in equipment resources would be called for for IAEA. We do continue to have concern in NRC about some technical problems associated with bulk handling facilities, particularly.

Mrs. **Bouquard**. In what, sir?

Mr. **Davis**. Bulk handling facilities, particularly, some technical problems associated with those which the Commission has——

Mrs. **Bouquard**. Accounting?

Mr. **Davis**. Yes, ma'am.

Mrs. **Bouquard**. That was the area that I was going to ask you about. Dr. Sessoms?

Dr. **Sessoms**. You will note from the answers that we talk to each other from time to time, Madam Chairman. [Laughter.]

I think in addition to what has been said, I think we have to focus seriously on facilities that will use plutonium. I do not think there is any way of avoiding its use and the IAEA is not presently prepared to deal with the problem. I think that we will have to work with them in the research and development area, in the manpower training area, and in the inspector recruiting area, so that they can cover the bases they are going to face. I think we are working with them now very diligently on enrichment plant safeguards. We are not there yet and neither is the IAEA. I think all these things are near-term and longer-term problems that we will just have to deal with, and I think we can but I think it will take a great deal of diligence that we are prepared to give.

Mrs. Bouquard. How about the forms of measurement of materials of the cycles?

Dr. Sessoms. I think in principal we have the science done. It is just going to be some engineering to get those things into the field so that the GI can use them, and IAEA inspectors are just like GI's. They walk into the field, it is hot, it is sweaty, it is rainy. They are not particularly happy being 5,000 miles away from home and they make mistakes. We have to try to make the instruments foolproof but I think the science is done and it is just the technology and the engineering that really has to be made suitable for IAEA use. We are working on that but we are not there yet.

Mrs. Bouquard. Thank you. Dr. Menzel?

Dr. Menzel. I do endorse what has been said. I might point to three factors that the Director of ACDA included in his testimony on March 18 of this year before the Subcommittee on International Economic Policy and Trade and also the Subcommittee on International Security and Scientific Affairs. Taking a somewhat broader perspective, what is needed to implement some of the points referred to by my colleagues is a firming up of the underlying base for cooperative verification, which safeguards is. He mentioned first, we need a renewed commitment by the member States to support effective and efficient IAEA safeguards. All States should support effective and efficient safeguards in their own interest. Second, we need a strengthened commitment by the member States to provide the international safeguards system with the resources that are necessary, the financial resources and the human resources. Third, we need a reaffirmed commitment by the IAEA to pursue its obligation in the most professional manner possible. It is recognized by the new Director-General of the IAEA, Mr. Blix, that the IAEA does need to implement improvements in its management, in its resource allocation, and in its deployment of the inspection force. These are some of the fundamental things that need to be addressed in order to provide effective and efficient safeguards. Thank you.

Mrs. Bouquard. Thank you so very much for your very excellent testimony. It is very obvious that you put a lot of time and experience into your remarks today, and I want to commend you not only for your testimony but for what you are individually and collectively doing for effective safeguards.

Thank you so very much. If there are no further comments, then, the subcommittee will continue its hearings on this same subject tomorrow morning. Our hearings will begin at 9:30 a.m. in the morning in this same room.

The subcommittee stands adjourned.

[Whereupon, at 3:15 p.m., the subcommittee recessed to reconvene at 9:30 a.m., on Wednesday, August 4, 1982, in room 2318, Rayburn House Office Building.]

[The following was received for the record:]

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August 13, 1982

Mr. Herman E. Roser
Asst. Secty. for Defense Programs
U.S. Department of Energy
Washington, D.C. 20585

Dear Mr. Roser:

We appreciated having Mr. Caudle testify on the Department of Energy's safeguards research and development programs at the Subcommittee's hearing on August 3, 1982. Chairman Bouquard would like to supplement the record of the hearing with some additional questions regarding the programs. We appreciate your cooperation on this matter,and we hope that this information can be provided by September 1, 1982.

We also request that the Subcommittee be provided with one copy of each unclassified report and publication on safeguards wholly or partially funded by the Department of Energy or its contractors, as well as a listing of all such documents, both classified and unclassified, commencing from the beginning of calendar year 1980. In addition, please place Dr. Harlan Watson of the Subcommittee staff on your mailing list to receive all unclassified safeguards documents in the future.

If you have any general questions regarding these requests, please contact me at 225-8056. If you have any questions regarding the specifics, please contact Dr. Harlan Watson of the Subcommittee staff at 225-3472.

Sincerely,

John V Dugan Jr

JOHN V. DUGAN, JR., Staff Director
Subcommittee on Energy Research
and Production

JVD:Wjs
Enclosures

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
CHAIRMAN BOUQUARD'S QUESTIONS ON
TECHNICAL ASPECTS OF NUCLEAR NONPROLIFERATION: SAFEGUARDS
Hearing held August 3, 1982

1. What, if any, role do the DOE Office of International Security Affairs and the DOE Office of International Affairs play in safeguards? Do either have any functions relating to safeguards research and development?

2. No mention was made of the results of the safeguards activities carried out at the Barnwell Nuclear Fuel Plant. What has been accomplished at Barnwell?

3. If you had it within your power and authority to devise a different scheme or organizational format for conducting domestic and international safeguards research and development, how would you change the current situation?

4. Mention was made of safeguards training programs sponsored by the DOE.

   a. Do all IAEA inspectors receive this training?
   b. How many participants have been IAEA inspectors?

5. How comparable is the portable, easy-to-operate equipment required for IAEA field inspections to the larger, more sophisticated in-plant equipment supplied for domestic use in sensitivity of measurements, reliability, and reproducibility? Is portable equipment a direct substitute for in-plant equipment, and if not, what is the relationship between them?

6. How does DOE interact with the Nuclear Regulatory Commission on R&D for domestic safeguards? What voice does NRC have, if any, in the development of the DOE program? Please provide some examples of NRC inputs that have affected DOE's domestic safeguards program.

7. Mention is made of a comprehensive system evaluation capability in direct support to safeguards improvement projects. Has this capability be exercised and, if so, what results were obtained?

8. The prepared statement provides OSS budget figures for safeguards R&D and field assistance for FY 1982 only. How do the FY 1982 funding levels compare with the FY 1981 levels and FY 1983 requests? What is the reason for changes?

9. Mention is made of the Interagency Steering Group for safeguards, the Action Plan Working Group, and the Technical Support Coordinating Committee.

   a. Please provide a complete description of the role and functions of each.

   b. Do these various coordinating bodies have any authority other than to try to reach a consensus?

   c. Which agency has the lead responsibility for safeguards R&D?

10. On page 8 of the prepared testimony, it is stated that in the international safeguards area, the DOE depends "upon inputs from the IAEA staff and reflect their priorities in the development and transfer of safeguards technology." Does DOE try to influence the IAEA staff in the establishment of their priorities, or does DOE play an entirely passive role?

11. On page 8, it is also stated that "IAEA priorities have tended to focus on the development of safeguards technology for application to bulk processing facilities and nuclear reactors." What attention is the IAEA giving to safeguards for plutonium fuel cycles?

12. What role, if any, does the National Bureau of Standards have in the preparation of material standards for calibrating non-destructive assay and chemical measurements across the fuel cycle?

13. What criteria, specifications, goals or targets has DOE set for safeguards technology and systems for plutonium fuel cycles?

14. It was stated that the largest DOE effort is the development of safeguards concepts for application at the planned Gaseous Centrifuge Enrichment Plant at Portsmouth, Ohio. How much is being expended in these efforts?

15. Does the OSS funding include the funds required for all expenses of department-wide safeguards and security systems at DOE facilities, or are these expenses allocated to individual programs throughout the Department?

16. It was stated that under existing bilateral agreements, DOE pursues joint R&D projects with nations such as Canada, the United Kingdom, West Germany and Japan. Could you give us some examples of such joint projects? Also, what sort of cost-sharing arrangements are made? Are these project costs on an equal footing? Which program offices fund these activities?

17. Please provide details on the scope of work conducted at DOE's New Brunswick Laboratory? What level of resources are expanded there?

Department of Energy
Washington, D.C. 20585

September 7, 1982

Honorable Marilyn Lloyd Bouquard
Chairman
Subcommittee on Energy Research
and Production
Committee on Science and Technology
House of Representatives
Washington, D.C. 20515

Dear Mrs. Bouquard:

On August 3, 1982, Robert Caudle, Director of the Office of Safeguards and Security, Department of Energy, testified before your committee regarding technical aspects of nuclear nonproliferation safeguards.

Subsequent to the hearing, you sent us additional questions to be answered to supplement the hearing record. Answers to those questions are enclosed.

If you have any questions, please call Hank Edler or Tom Pretorius of my staff on 252-4277. They will be happy to assist you.

Sincerely,

Thomas H. Pretorius
for Robert G. Rabben
Assistant General Counsel
for Legislation

Enclosures

cc: Mr. John V. Dugan
Staff Director

QUESTIONS AND ANSWERS

RESULTING FROM THE

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION

CHAIRMAN BOUQUARD'S QUESTIONS ON

TECHNICAL ASPECTS OF NUCLEAR NONPROLIFERATION: SAFEGUARDS

HEARING HELD AUGUST 3, 1982

Question 1

What, if any role do the DOE Office of International Security Affairs and the DOE Office of International Affairs play in safeguards? Do either have any functions relating to safeguards research and development?

Answer

DOE's Office of Safeguards and Security (OSS) is the primary DOE organization responsible for technical aspects of safeguards (both domestic and international) and conducts safeguards R&D. Neither the DOE's Office of International Security Affairs (ISA), nor the Office of International Affairs (IA) has any direct function related to safeguards R&D.

Regarding international safeguards, the Office of International Security Affairs is concerned from the standpoint of intelligence, export control, and international security policy. The office conducts an assessment and makes recommendations to the Secretary concerning the export of nuclear equipment and materials or providing assistance to foreign nuclear activities under DOE 10 CFR, Part 810, or other export-control regimes of Commerce or State. The Office is also involved in the formulation of nonproliferation and export control policy that considers international safeguards.

The Office of International Affairs is concerned with international nuclear policy, including nonproliferation policy, and is a member of the Interagency Steering Group on Safeguards, as is DOE's Office of Safeguards and Security.

Because of the close interrelationship of the responsibilities in the nonproliferation area among the DOE's Offices of IA, ISA, and OSS, continual close cooperation is carried out among these offices in the conduct of their nonproliferation and safeguards-related activities.

Question 2

No mention was made of the results of the safeguards activities carried out at the Barnwell Nuclear Fuel Plant. What has been accomplished at Barnwell?

Answer

During the past five years. DOE has actively supported, in conjunction with Barnwell, the development of two major safeguards systems at the Barnwell Nuclear Fuel Plant to determine the feasibility and practicality of employing a full-scale integrated physical protection and materials accountability and control system for safeguarding a nuclear fuels reprocessing plant. These systems, known as APPS (Advanced Physical Protection System) and CNMCAS (Computerized Nuclear Materials Control and Accounting System), are substantially completed, except for additional tests on various unit operations and debugging of computer software and hardware prior to qualification for use in planned full-scale demonstration in FY 1983. These systems incorporated the most advanced technology including computers, process material flow monitors, intrusion detection devices, and personnel access control systems. The CNMCAS has been fully installed with more than 500 data points which provide process information for computerized assessment. The APPS includes installed access control components such as voice-print analysis, sophisticated detection devices, intrusion alarms, and display monitoring consoles that maintain continuous surveillance over personnel movements and authorization throughout the plant. These systems are a promising beginning.

The DOE national laboratories have contributed significantly in assisting BNFP in developing their safeguards system through cooperative efforts by Los Alamos National Laboratory (LANL), Sandia National Laboratories (SNL), Oak Ridge National Laboratory (ORNL), Brookhaven National Laboratory (BNL), Lawrence Livermore National Laboratory (LLNL), and others such as the DOE facilities at Rocky Flats (RF), Savannah River (SR), and Richland (RL).

Question 2/Answer (Continued)

In addition to this close, direct cooperative relationship with national laboratories, the BNFP staff has been called upon by these laboratories to implement international programs in support of U.S. nuclear nonproliferation objectives. International training courses have been conducted by the BNFP staff under contract to Los Alamos, Sandia, and the International Safeguards Project Office of Brookhaven National Laboratory. Classes on Advanced Nuclear Materials Control and Accounting have been prepared and conducted by BNFP personnel in New Mexico in conjunction with LANL. Under contract with Brookhaven, BNFP personnel have assisted the IAEA in establishing its overall training program for international safeguards inspectors and have conducted seminars for IAEA staff personnel on near-real-time accountability and in-process inventory systems.

Question 3

If you had it within your power and authority to devise a different scheme or organizational format for conducting domestic and international safeguards research and development, how would you change the current situation?

Answer

Based on accomplishments over the past several years, the current arrangement for conducting the safeguards R&D appears quite satisfactory. The DOE laboratories carry out the work both for our domestic and international programs and also for the International Atomic Energy Agency (IAEA) support program which Department of State (DOS) funds, and DOE/Office of Safeguards and Security manages technically. Coordination among the national laboratories is excellent and results in well-based, well-coordinated R&D which is user-oriented and supported by a strong technology base program. Nevertheless, I recently initiated a review of our overall management of this program with the objective of enhancing it wherever needed.

Question 4

Mention was made of safeguards training programs sponsored by the DOE.

a. Do all IAEA inspectors receive this training?

b. How many participants have been IAEA inspectors?

Answer

DOE conducts two major training programs in support of international safeguards. The first is training under the Nuclear Non-Proliferation Act of 1978 for personnel from nations with developing peaceful nuclear programs; the second is training designed specifically for IAEA inspectors. Regarding the latter, DOE provides training for IAEA inspectors at its laboratories as requested by IAEA under the U.S. Program of Technical Assistance for IAEA Safeguards (POTAS) funded by the Department of State. Since inception of the program in 1980, all new--and some experienced--IAEA inspectors have received this training. Approximately 120 inspectors have been trained in total.

Question 5

How comparable is the portable, easy-to-operate equipment required for IAEA field inspections to the larger, more sophisticated in-plant equipment supplied for domestic use in sensitivity of measurements, reliability, and reproducibility? Is portable equipment a direct substitute for in-plant equipment and, if not, what is the relationship between them?

Answer

Equipment for IAEA field inspections does not have the capability to equal the accuracy and sensitivity of in-plant measurement equipment and, hence, cannot substitute for such equipment. Portable inspector equipment is used for rapid, onsite verification to confirm the validity of measurements by in-plant equipment, with corroboration of their accuracy and sensitivity obtained from samples sent to the IAEA's laboratory at Seibersdorf.

The IAEA has its sophisticated measurement equipment, equal to in-plant equipment, in their Seibersdorf Analytical Laboratory. Inspectors verify the accuracy and precision of the operator's measurements made using in-plant equipment by use of both the portable instruments and sample analysis. Currently, IAEA inspectors take about 900 samples per year of nuclear material and send them to their laboratory for about 2,000 analyses per year.

Question 6

How does DOE interact with the Nuclear Regulatory Commission on R&D for domestic safeguards? What voice does NRC have, if any, in the development of the DOE program? Please provide some examples of NRC inputs that have affected DOE's domestic safeguards program.

Answer

The DOE and NRC have a memorandum of understanding to coordinate activities including R&D in support of safeguards. Coordination is accomplished primarily through a Liaison Board. Meetings between staff members which include the exchange of R&D information are held each month alternatively at DOE and NRC offices. DOE and NRC have a mutual concern that safeguards and security operations within the Government sector and the private sector are comparable in effectiveness. DOE assesses Government programmatic activities through both Headquarters and field evaluations. Identified weaknesses are to a large extent addressed through provisions of technology exchange and both DOE and NRC training programs. Safeguards technology transferred to the Government contractors and private sectors as a result of DOE and NRC interface and collaboration embodies many forms to assist in planning, installing and operating physical protection, containment/surveillance and accountability systems consisting of conceptual and engineering designs, equipment specifications and operational performance standards.

Some examples of NRC inputs that have affected DOE's domestic safeguards program include threat studies such as the recently completed study of the insider threat.

Another example is the NRC Policy and Planning Guidance, 1982, which among other things, recognizes that the effectiveness of the safeguards system, just as the safety system, is highly dependent on the performance of the human factors; and that staff should assure that lessons learned from the reactor human factors

Question 6/Answer (Continued)

program are incorporated as appropriate in the safeguards programs. These and related DOE inputs have influenced current planning and designs for improved safeguards and security systems. NRC has also expressed interest and encouraged DOE to continue R&D efforts in detection of high explosives to thwart potential threats of related contraband at nuclear facilities. In addition, through their inspection procedures and experience in the field, NRC has contributed to DOE/OSS efforts in the use of standards and calibration procedures to improve instrumentation and related analytical measurement techniques to determine location and amounts of nuclear materials in the decommissioning of nuclear facilities.

Question 7

Mention is made of a comprehensive system evaluation capability in direct support to safeguards improvement projects. Has this capability been exercised and, if so, what results were obtained?

Answer

The comprehensive evaluation approach has been and is being applied at the following DOE sites: (a) Idaho Falls; (b) Rocky Flats; (c) Oak Ridge; (d) Portsmouth Enrichment Plant, and (e) Lawrence Livermore National Laboratory. Results obtained were:

- Evaluated the system's effectiveness against the insider/outsider combination adversary;
- Developed cost-effective system design options, permitting selection of an optimized system design to suit the site specific requirements;
- Defined highest probability of response to safeguards system alarms;
- Integrated physical security and material accountability alarm assessments and response options against a broad spectrum of threats;
- Provided an analytical approach for future safeguards and security R&D program planning and resource allocation;
- Provided facility operators with input data such as frequency of occurrence, deterrence value of safeguards subsystems and consequences of theft, diversion and sabotage, and other related factors to develop specific facility system designs; and
- Provided technical justification to support long-range program planning decisions.

Question 8

The prepared statement provides OSS budget figures for safeguards R&D and field assistance for FY 1982 only. How do the FY 1982 funding levels compare with the FY 1981 levels and FY 1983 requests? What is the reason for changes?

Answer

The $22.5 million safeguards R&D and field assistance portion of the FY 1982 budget compares with approximately $23.9 million in FY 1981 and $24.8 million requested in FY 1983. The primary objective of efforts under this program is to provide expert technical assistance to field operations. Headway made in FY 1982 will be accelerated in FY 1983 to identify deficiencies at key DOE facilities and to provide cost-effective improvements using program developed technology. These efforts include assistance to field offices and facility operators in the engineering design, procurement and installation specifications, prototype testing and operational evaluation of systems for specific DOE sites. Actual implementation and related funding are the responsibility of the field offices and program offices within DOE.

Question 9

Mention is made of the Interagency Steering Group for Safeguards, the Action Plan Working Group, and the Technical Support Coordinating Committee.

a. Please provide a complete description of the role and functions of each.

b. Do these various coordinating bodies have any authority other than to try to reach a consensus?

c. Which agency has the lead responsibility for safeguards R&D?

Answer

The Interagency Steering Group for Safeguards is chaired by the Department of State (DOS) and includes senior-level representatives from the Department of Energy (DOE), Nuclear Regulatory Commission (NRC), Arms Control and Disarmament Agency (ACDA), and the National Security Council (NSC). Its primary function is to serve as a program coordination group among those agencies which carry out activities directly or indirectly related to international safeguards and security matters. The group meets at the call of the chairperson (which averages about four times a year).

The Action Plan Working Group is a mid-management level group under the chairmanship of the ACDA. It operates as a working group whose responsibilities include identification of U.S. activities that might serve to improve the effectiveness of International Atomic Energy Agency (IAEA) safeguards activities. The membership includes representation from the DOS, DOE, and the NRC. The group's findings are available to the Interagency Steering Group.

The Technical Support Coordinating Committee is a mid-management committee chaired by the DOS with the specific mission of directing the allocation of DOS appropriated funds to R&D projects specifically aimed at improving the effectiveness of IAEA safeguards. NRC, ACDA, and DOE participate in this group which reports periodically to the Interagency Steering Group for any needed policy guidance.

Question 9/Answer (Continued)

The work of the three groups discussed above is very closely interrelated and, accordingly, close liaison is maintained by the participants. In general, the groups strive to reach a consensus, but failure to achieve a consensus would necessarily lead to the issues being referred to higher levels (and possibly the White House) for resolution. DOE has the lead responsibility for domestic safeguards R&D and, as appropriate, takes account of NRC's confirmatory safeguards R&D. For international safeguards R&D, DOE, NRC, and ACDA contribute to the total U.S. effort as described in the hearings testimony.

Question 10

On page 8 of the prepared testimony, it is stated that in the international safeguards area, the DOE depends "upon inputs from the IAEA staff and reflect their priorities in the development and transfer of safeguards technology." Does DOE try to influence the IAEA staff in the establishment of their priorities, or does DOE play an entirely passive role?

Answer

DOE plays an active role in identifying the U.S. technology available for application to IAEA safeguards needs as well as, on the basis of fuel cycle facility studies, equipment development successes, and the like, suggesting priorities that in DOE's view seem appropriate. IAEA requests for technical assistance are reviewed by the Technical Support Coordinating Committee (TSCC) and input made on scope and relevancy to U.S. views on IAEA needs.

There are ample official channels for technical communication through correspondence and the many international meetings called by the IAEA for that purpose. Meetings include consultant meetings, advisory group meetings, and research coordination meetings. DOE staff and laboratories play a strong role in such technical interfaces.

Under unusual circumstances, DOE undertakes R&D unilaterally on equipment clearly needed for IAEA safeguards. For instance, during a visit to DOE in 1979, the Deputy Director General for Safeguards requested U.S. legislative relief for air shipment of small samples of plutonium, a serious need of IAEA safeguards. The possibility of legislative relief was found to be unpromising, so DOE immediately initiated work on a technical solution, the development of the PAT-2 shipping container which has been provided to the IAEA for timely transport by air of inspector samples of plutonium.

Question 11

On page 8, it is also stated that "IAEA priorities have tended to focus on the development of safeguards technology for application to bulk processing facilities and nuclear reactors." What attention is the IAEA giving to safeguards for plutonium fuel cycles?

Answer

IAEA now applies safeguards to small-scale facilities in the plutonium fuel cycles for LWR and fast breeder reactors. Safeguards equipment has been developed by DOE under the POTAS program, procured by the IAEA and put into widespread operational use. Other equipment is being developed now under both the DOE and the POTAS program and future needs will arise. Growth in the plutonium fuel cycle is expected in the 1980's, using plutonium from spent fuel reprocessed in existing facilities at Windscale, U.K., and Cap La Hague, France. Further growth is expected in the 1990's when larger plutonium fuel cycle facilities will be completed in nonnuclear weapon states. Similar technical support programs sponsored by U.K., FRG, and Japan are addressing safeguards for plutonium fuel cycle activities.

Question 12

What role, if any, does the National Bureau of Standards have in the preparation of material standards for calibrating nondestructive assay and chemical measurements across the fuel cycle?

Answer

DOE has contracted with the National Bureau of Standards (NBS) to collaborate with the DOE New Brunswick Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, and others, and NBS has been instrumental in the development, preparation, and certification of primary standard reference materials used in analytical and isotopic measurements by Government agencies, international organizations, and private industrial companies both in the U.S. and internationally. NBS is currently participating in the use of standards and calibration of instrumentation for conventional chemistry and nondestructive assay (NDA) techniques at various DOE laboratory and production sites through DOE/OSS financial support and management.

Additionally, NBS is assisting OSS in evaluating methods for bulk material measurements application to inventories in the fuel cycle and consulting with personnel at DOE weapon material production and recovery facilities through onsite visits and participation in calibration test and evaluation programs for NDA analysis.

Question 13

What criteria, specifications, goals, or targets has DOE set for safeguards technology and systems for plutonium fuel cycles?

Answer

In the domestic safeguards area, the highest DOE level of physical protection and related security system and accountability system requirements have been specified for significant quantities of plutonium (2 kgs or more). In general, these require that sites successfully guard against overt and covert adversary sequences, and that bi-monthly inventories be conducted.

With regard to international safeguards, DOE supported the adoption by IAEA of the following guidelines as goals for their safeguards activities (DOE uses these same goals in its international safeguards support activities):

a. Assurance that an assumed "abrupt" diversion of 8 kgs of separated plutonium at one time, or over a short period of time, would have a high probability of being detected within a period on the order of one to three weeks;

b. Assurance that an assumed "protracted" diversion of separated plutonium, at a minimum rate of 8 kgs plutonium per year, would have a high probability of being detected before the total diverted equalled or exceeded 8 kgs; and

c. Assurance that the diversion of sufficient spent fuel assemblies or fuel rods to contain 8 kgs plutonium would have a high probability of being detected within a period on the order of one to three months.

In coordination with responsible program groups, OSS has continued to carry out research and development in support of approved DOE programs involving plutonium, such as breeder fuel development and base technology for reprocessing. This includes safeguards and security design support at DOE facilities such as the Fuels and Materials Examination Facility and the Fast Flux Test Facility in

Question 13/Answer (Continued)

Washington, and the Consolidated Fuel Reprocessing Program in Oak Ridge. Support includes component and systems development for physical protection and materials control and accountability. Specifications for equipment and instruments being developed have wide application to both defense and nuclear energy sectors. They are designed for greater accuracy and sensitivity than currently available and focus on automated hands-off operation to the extent possible. Expansion of capability in both physical protection and measurements include explosives detection, personnel identification, nondestructive measurements for the various plutonium solids and solutions of the fuel cycle. Remotely operated, automated near real-time accountability systems can be backed up by recently developed isotope correlation techniques. These techniques can predict the amount of plutonium produced in reactors. The attributes of physical measurement technology and correlation techniques minimize inventory and shipper receiver differences for plutonium and verifies the operational history of nuclear reactors, thus improving sensitivity for detecting any loss or diversion.

Question 14

It was stated that the largest DOE effort is the development of safeguards concepts for application at the planned Gaseous Centrifuge Enrichment Plant at Portsmouth, Ohio. How much is being expended in these efforts?

Answer

It is true that the largest international safeguards research and development project is the development of safeguards concepts and inspection strategies for the Gaseous Centrifuge Enrichment Plant (GCEP). The work being conducted at various laboratories was funded at approximately $1.8 million and $2.2 million in FY 1981 and FY 1982, respectively. The planning figure for FY 1983 is approximately $2.3 million.

Question 15

Does the OSS funding include the funds required for all expenses of Department-wide safeguards and security systems at DOE facilities, or are these expenses allocated to individual programs throughout the Department?

Answer

The Nuclear Safeguards and Security program does not fund the actual plant, capital equipment, and operating expenses of agency-wide safeguards and security systems at agency facilities. The safeguards and security systems in other Department programs, e.g., weapons and nuclear materials programs, are requested by, budgeted for, and implemented by those programs.

The OSS FY 1982 support of $45.6 million is only 19% of the total agency request of $234 million.

Question 16

It was stated that under existing bilateral agreements, DOE pursues joint R&D projects with nations such as Canada, the United Kingdom, West Germany, and Japan. Could you give us some examples of such joint projects? Also, what sort of cost-sharing arrangements are made? Are these project costs on an equal footing? Which program offices fund these activities?

Answer

We now have active bilateral technical exchange agreements with the U.K., Federal Republic of Germany (FRG), and Euratom in safeguards technology; we also have informal agreements with Canada and France and have active discussions underway with Australia and Japan.

A specific example of a joint project involved the FRG where we have worked together to design and test unattended portal monitors for control of access to or from fuel cycle facilities. Another is with the U.K., which has involved exchange of technical staff between safeguards laboratories.

No direct transfers of funds are made, but attempts are made to achieve a quid pro quo between the data, hardware, and personnel exchanged. The Office of Safeguards and Security funds and manages these exchanges on the U.S. side.

Question 17

Please provide details on the scope of work conducted at DOE's New Brunswick Laboratory? What level of resources are expended there?

Answer

The DOE New Brunswick Laboratory (NBL) located on the Argonne National Laboratory (ANL) site is a DOE-owned and operated laboratory with programmatic responsibility to the DOE Office of Safeguards and Security. NBL specializes in the analytical chemistry of materials related to the U.S. nuclear energy and weapons production programs. The scope of work conducted at NBL includes:

- development and dissemination of improved measurement technology for nuclear materials;
- preparation, characterization, and distribution of analytical reference and calibration material standards;
- evaluation of ongoing level of measurement performance through extensive interlaboratory comparison of government and private laboratories engaged in handling nuclear materials;
- highly accurate and precise measurements of samples for inventory verification and confirmation supporting the U.S. safeguards inspection and audit programs; and
- technology exchange and training for U.S. and international safeguards participants in nuclear materials measurements and standards.

The level of funding at NBL for FY 1982, supported by DOE/OSS, is $2.6 million.

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MINORITY STAFF DIRECTOR

August 13, 1982

Dr. Nunzio J. Palladino, Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Chairman:

We appreciated having Mr. Davis testify on the Nuclear Regulatory Commission's safeguards research and development programs at the Subcommittee's hearing on August 3, 1982. Chairman Bouquard would like to supplement the record of the hearing with some additional questions regarding the programs. We appreciate your cooperation on this matter and we hope that this information can be provided by September 1, 1982.

We also request that the Subcommittee be provided with one copy of each unclassified report and publication on safeguards wholly or partially funded by the Nuclear Regulatory Commission or its contractors, as well as a listing of all such documents, both classified and unclassified, commencing from the beginning of calendar year 1980. In addition, please place Dr. Harlan Watson of the Subcommittee staff on your mailing list to receive all unclassified safeguards documents in the future.

If you have any general questions regarding these requests, please contact me at 225-8056. If you have any questions regarding the specifics, please contact Dr. Harlan Watson of the Subcommittee staff at 225-3472.

Sincerely,

John V Dugan Jr

JOHN V. DUGAN, JR., Staff Director
Subcommittee on Energy Research
and Production

JVD:Wjs
Enclosures

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
CHAIRMAN BOUQUARD'S QUESTIONS ON
TECHNICAL ASPECTS OF NUCLEAR NONPROLIFERATION: SAFEGUARDS
Hearing Held August 3, 1982

1. Mr. Burnett stated that the NRC still stands behind the statement made in a March 2, 1982 letter to congressional oversight committees from the NRC which stated that because plutonium "can be transformed rapidly into weapons, we cannot count reliably on inspection alone to provide warning of diversion of HEU and separated plutonium in time to prevent weapons assembly if the necessary preparatory work has been done."
    a. Please provide the Subcommittee with a complete text of the letter.
    b. How well does existing Federal safeguards R&D address needed improvements so that the NRC would change its mind?
    c. What would the NRC have done that is not being done?

2. It was stated that the main purpose of NRC's research and technical assistance program is to develop technical information which will provide a sound basis for regulatory requirements.
    a. How much of this work is aimed at plutonium fuel cycles? At light water reactor cycles? At heavy water reactor cycles?

    b. How good is this balance for today's nuclear power program, and how good is it for future commercial use of plutonium?

3. What attention has NRC's coordinating group given to safeguards technology and criteria for plutonium fuel cycles? If little attention has been given, why? Does NRC have an organizational bias against plutonium?

4. It was stated that NRC is not involved in any safeguards technological agreements with other nations. Should it be involved? What would be the benefits of NRC involvement? Why is it not involved?

5. It was stated that NRC is not aware of any particular problems in getting advance safeguards equipment and techniques into domestic use.
    a. Do you know of any problems of getting such equipment into international use?
    b. What is NRC's judgement on ways to get private companies to invest in commercialization of government developed equipment when sales may be only a few units a year?

6. In a situation of diminishing safeguards R&D, how can the NRC maintain the technical competence needed to judge IAEA safeguards?

7. What is NRC's position on conducting safeguards work in anticipation of plutonium fuel cycles, whether breeder or recycle?

8. What does the NRC think of DOE funded safeguards RD&D at Barnwell? How useful are the results? What gaps remain in NRC's view for safeguards technology for plutonium fuel cycles?

9. It is noted that safeguards areas which continue to require improvement involve materials measurement and accountability, protection against "insider" sabotage at reactors and IAEA safeguards.

   a. Has the NRC developed standards, or criteria, or goals, for such safeguards instruments and equipment?
   b. If so, how does currently available instrumentation and equipment compare with the standards? What additional development is needed? How important is it?
   c. If NRC has developed criteria, have they been accepted by other agencies?
   d. If NRC has not developed them, has this been done by any other U.S. agency? By agencies of other governments? By the IAEA?

10. NRC's discussion of long range plans does not mention observation of IAEA inspectors as they inspect U.S. facilities under the voluntary agreement.

    a. Does NRC accompany IAEA inspectors?
    b. If so, what observations do NRC personnel make? To whom? What is done with this information? How is it shared, if at all, with DOE and its contractors?
    c. Also, in terms of long range planning, is NRC planning to develop criteria, standards, goals, etc., for advanced nuclear fuel cycles, including those using plutonium?

11. Exactly who has the lead responsibility among all the involved governmental entities for safeguards research and development? Do the various coordinating groups have any authority other than to try to reach a consensus?

12. If it was within your power and authority to devise a different scheme or organizational format for conducting domestic and international safeguards research and development, how would you change the current situation?

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

AUG 3 1 1982

Mr. John V. Dugan, Jr., Staff Director
Subcommittee on Energy Research
and Production
Committee on Science and Technology
United States House of Representatives
Washington, D. C. 20515

Dear ~~Mr. Dugan~~: JACK

This responds to your letter of August 13, 1982, which contained a list of questions to supplement the hearing on August 3 and a request for reports and publications on safeguards.

The answers to your questions are enclosed. Your request for safeguards reports and publications is being fulfilled and will be handled by separate correspondence at an early date. Also, we are placing Dr. Harlan Watson of the subcommittee on our mailing list to receive unclassified safeguards reports in the future.

Sincerely,

Bill

William J. Dircks
Executive Director for Operations

Enclosure:
Answers to Questions

Question 1: Mr. Burnett stated that the NRC still stands behind the statement in a March 2, 1982 letter to congressional oversight committees from the NRC which stated that because plutonium "can be transformed rapidly into weapons, we cannot count reliably on inspection alone to provide warning of diversion of HEU and separated plutonium in time to prevent weapons assembly if the necessary preparatory work has been done."

a. Please provide the Subcommittee with a complete text of the letter.

b. How well does existing Federal safeguards R&D address needed improvements so that the NRC would change its mind?

c. What would the NRC have done that is not being done?

Answer: a. A complete text of the letter is provided as an attachment to the NRC response to the question of the Subcommittee.

b. Federal safeguards R&D efforts have been successful in developing a broad range of instruments, equipment and techniques to provide the IAEA a technical capability to effectively apply safeguards at facilities currently under its jurisdiction. This includes coverage for the pilot, prototype, demonstration and small commercial HEU and plutonium facilities presently subject to IAEA safeguards. However, some of these instruments have only recently been tested and approved by the IAEA for routine use, and others are still undergoing IAEA testing and certification.

The development of technical capabilities for the IAEA to effectively apply safeguards to the large bulk handling facilities of the future remains a most difficult challenge. Achievement of IAEA goals at these facilities, especially the timeliness goal, probably will require the development of dynamic, near real time material verification and accounting programs and broader utilization of containment/surveillance systems. Although efforts to develop this technology have been underway for several years, increased attention will have to focus on this development need.

Many other factors in addition to technology and equipment development must be addressed to attain reliable and timely inspection systems to provide warning of diversion of HEU and separated plutonium. The use of continuous or frequent inspection at sensitive facilities will require more manpower and equipment than is currently available. The cooperation of national authorities and plant operators is essential and legal provisions must be made for the introduction of new technology and techniques at facilities; greater access of inspectors to facility operations will be needed for rapid accounting systems.

(Question 1, answer b continued)

Inspectors must be trained and provisions must be made for the timely reporting and analysis of inspection results. Information systems must be put into operation to facilitate the flow of safeguards information within the IAEA and to member states.

c. The NRC recognizes that these problems do not have short-range solutions; therefore, we will continue to support the strengthening of IAEA safeguards. We are generally satisfied with the way the R&D program has evolved. It should also be noted that, even after all necessary improvements have been made, IAEA safeguards will continue to constitute only one element of an effective non-proliferation policy and that factors other than safeguards will remain important in providing adequate assurances against diversion of plutonium.

Question 2: It was stated that the main purpose of NRC's research and technical assistance program is to develop technical information which will provide a sound basis for regulatory requirements.

a. How much of this work is aimed at plutonium fuel cycles? At light water reactor cycles? At Heavy water reactor cycles?

b. How good is this balance for today's nuclear power program, and how good is it for future commercial use of plutonium?

Answer: a. At present, NRC has one safeguards technical assistance project aimed at domestic reprocessing of LWR spent fuel. This project will assess certain generic issues related to the application of NRC safeguards regulations to reprocessing and will develop information that will help the NRC identify areas where safeguards regulations may need to be modified to be effective for reprocessing facilities. Most of our safeguards contractual projects, exclusive of those examining safeguards for fuel processing sites, are aimed at physical protection against sabotage of light water reactors; however, many of the results could apply to other cycles. There are no safeguards projects aimed exclusively at heavy water reactor cycles because there are no such reactor cycles in the present domestic licensed program.

b. We believe that this balance is appropriate for today's nuclear power program. Future commercial use of plutonium in the U.S. will probably require additional safeguards research in the areas of material measurement and control. Such research would be a logical extension of the generic assessment project described above.

Question 3: What attention has NRC's coordinating group given to safeguards technology and criteria for plutonium fuel cycles? If little attention has been given, why? Does NRC have an organizational bias against plutonium?

Answer: NRC's Safeguards Technical Assistance and Research Coordinating (STAR) Group has reviewed and recommended approval of the technical assistance project referred to in the answer to Question 2.a. above. In general, little attention has been given to domestic safeguards technology and criteria for plutonium fuel cycles primarily because of the 1977 Presidential statement on nuclear power policy to "defer indefinitely the commercial reprocessing and recycling of the plutonium produced in the U.S. nuclear power programs." We are not aware of an NRC organizational bias against plutonium.

Question 4: It was stated that NRC is not involved in any safeguards technological agreements with other nations. Should it be involved? What would be the benefits of NRC involvement? Why is it not involved?

Answer: The main purpose of NRC's research and technical assistance programs is to develop technical information which will aid the staff and Commission in resolving domestic regulatory issues and providing support to U.S. efforts in strengthening IAEA safeguards. The NRC does have general information exchange agreements with many countries, including exchange of safeguards information in some instances. Accordingly, we believe that the present role of NRC in exchanging safeguards information is the appropriate one. Our experience has been that the exchange of safeguards information has been of mutual advantage and enables NRC staff to maintain an awareness of current technical developments without the need to conduct, for example, joint safeguards research projects with other countries.

Question 5: It was stated that NRC is not aware of any particular problems in getting advance safeguards equipment and techniques into domestic use.

a. Do you know of any problems of getting such equipment into International use?

b. What is NRC's judgement on ways to get private companies to invest in commercialization of government developed equipment when sales may be only a few units a year?

Answer: a. As a result of our interagency activities to strengthen IAEA safeguards, we have observed that a number of problems are encountered in getting advance safeguards equipment and techniques put into routine international use, including the following technical problems:

- o New equipment and techniques must be field tested in foreign facilities, evaluated and certified for IAEA use over a wide variety of environmental and plant operating conditions.
- o Calibration and quality control standards must be developed to cover a wide variety of material forms and concentrations.
- o New equipment and techniques must sometimes be modified to meet facility-specific applications.
- o IAEA inspectors must be trained and their skills must be improved.
- o IAEA maintenance capabilities must be expanded and upgraded.

In addition to technical problems, a number or administrative, policy and legal problems are encountered, including the following:

- o Some plant operators and States limit IAEA access to parts of their facilities.
- o IAEA Subsidiary Arrangements must sometimes be reinterpreted or modified to provide for the use of new instruments and techniques.
- o IAEA budget limitations on number of inspectors and funding for purchase of new instrumentation affect capabilities for putting new instrumentation into use.
- o The supply of new instrumentation is frequently limited and lead-times are long.
- o New inspection procedures must be developed and incorporated as IAEA standard practices.

b. As a regulatory agency, the NRC does not play an advocacy role in the commercialization of government developed equipment. We believe that this role is more properly a function of the Department of Energy. However, we do, as appropriate, suggest in our regulatory guidance documents various ways in which our regulatory requirements can be achieved.

Question 6: In a situation of diminishing safeguards R&D, how can the NRC maintain the technical competence needed to judge IAEA safeguards?

Answer: Although the domestic safeguards R&D is diminishing, the international R&D and technical assistance efforts are actually undergoing a slight expansion. The NRC maintains competence needed to judge the technical aspects of IAEA safeguards by continued participation in the U.S. program for technical assistance to IAEA safeguards (POTAS), by taking part in various consultants meeting with the IAEA, by participation in information exchange programs, by examination of the IAEA program as applied in the U.S. under the US/IAEA Safeguards Agreement, and through various other informational sources.

Question 7: What is NRC's position on conducting safeguards work in anticipation of plutonium fuel cycles, whether breeder or recycle?

Answer: Our position is that NRC should be capable of responding to safeguards license applications concerning plutonium fuel cycles in a timely, efficient manner. The NRC believes that our ongoing study on generic issues associated with reprocessing will enable us to resolve such issues in time to fulfill our regulatory responsibilities. Also, it should be noted that we are currently in the process of performing a preconstruction licensing review of the Clinch River Breeder Reactor plant.

Question 8: What does the NRC think of DOE funded safeguards RD&D at Barnwell? How useful are the results? What gaps remain in NRC's view for safeguards technology for plutonium fuel cycles?

Answer: The DOE funded R&D safeguards projects at Barnwell have demonstrated the feasibility of advanced concepts, both in the areas of physical protection and in material control and accounting and have improved our confidence that adequate and effective safeguards can be maintained for a large reprocessing plant. (Also, some of the Barnwell results are applicable to international safeguards.) Although there may be a need for further development of safeguards technology relative to plutonium reprocessing, the NRC believes that our ongoing study will enable us to resolve regulatory issues in time to fulfill our regulatory responsibilities. It should be noted that for the past several years, the private licensed sector has not been engaged in any significant plutonium utilization.

Question 9: It is noted that safeguards areas which continue to require improvement involve materials measurement and accountability, protection against "insider" sabotage at reactors and IAEA safeguards.

a. Has the NRC developed standards, or criteria, or goals, for such safeguards instruments and equipment?

b. If so, how does currently available instrumentation and equipment compare with the standards? What additional development is needed? How important is it?

c. If NRC has developed criteria, have they been accepted by other agencies?

d. If NRC has not developed them, has this been done by any other U.S. agency? By agencies of other governments? By the IAEA?

Answer: a. No, the NRC has not been involved in equipment development. Although a relatively limited NRC technical assistance effort has been pursued to translate measurement and assay standards from a highly controlled laboratory environment, e.g., NBS, to the relatively uncontrolled environment of operational fuel cycles, this effort has not been oriented toward instrument or equipment development.

b. In light of a., above, these questions are not relevant.

c. In light of a., above, this question is not relevant.

d. The NRC is not aware of standards and criteria established by other U.S. agencies or governments for specific instruments or equipment. However, some guidelines have been developed in IAEA meetings and past POTAS discussions as to desired capabilities for measurements at various points in the fuel cycle.

Question 10: NRC's discussion of long range plans does not mention observation of IAEA inspectors as they inspect U.S. facilities under the voluntary agreement.

a. Does NRC accompany IAEA inspectors?

b. If so, what observations do NRC personnel make? To whom? What is done with this information? How is it shared, if at all, with DOE and its contractors?

c. Also, in terms of long range planning, is NRC planning to develop criteria, standards, goals, etc., for advanced nuclear fuel cycles, including those using plutonium?

Answer:

a. Yes, the NRC does accompany IAEA inspectors to NRC licensed facilities.

b. NRC has the opportunity to observe the procedures and techniques used by the IAEA. Observations of significant interest are informally passed on to other U.S. agencies, including DOE, through several interagency groups involved in the Agreement implementation. The Executive Branch has a study underway to evaluate certain IAEA inspection activities under the U.S. Agreement, which the NRC is monitoring. Also, NRC is pursuing a study of the effectiveness of the application of IAEA safeguards at selected U.S. licensed facilities.

c. In domestic safeguards, NRC is in the process of rulemaking which will establish improved performance goals and standards for both existing plants and advanced nuclear fuel cycles, including those using plutonium.

In the international area, NRC staff will continue to participate in interagency efforts to assist the IAEA in the development of safeguards approaches for advanced nuclear fuel cycles, including those using plutonium.

Question 11: Exactly who has the lead responsibility among all the involved governmental entities for safeguards research and development? Do the various coordinating groups have any authority other than to try to reach a consensus?

Answer: NRC's domestic research and technical assistance efforts are oriented toward developing technical information which will aid the staff and Commission in resolving regulatory issues and promote a sound basis for NRC's regulatory requirements. Consequently, NRC's efforts are not generally intended to develop safeguards-related hardware. Instead, we look primarily to DOE and the private licensed nuclear industry for such development. With regard to international safeguards, Department of State (DOS) has the lead responsibility in working with other agencies, i.e., DOE, ACDA, and NRC, to manage the U.S. Program for Technical Assistance to IAEA Safeguards through the Technical Support Coordinating Committee, which has considerable authority over the selection and conduct of R&D projects for the IAEA Safeguards program.

Question 12: If it was within your power and authority to devise a different scheme or organizational format for conducting domestic and international safeguards research and development, how would you change the current situation?

Answer: With respect to conducting domestic safeguards R&D, we see no reason to devise a different scheme or organizational format. We generally subscribe to the current arrangement whereby DOE and industry accomplish hardware R&D while NRC concentrates on studies associated with rules and guides formulation, licensing, and inspection to improve its regulatory functions.

We also generally agree with the current arrangement for conducting safeguards R&D to strengthen international safeguards. This activity, by its very nature, should continue to be managed by an interagency group with DOS in the lead policy role and with DOE and NRC in strong technical support roles.

CHAIRMAN

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

March 2, 1982

The Honorable John D. Dingell
Chairman
Committee on Energy and Commerce
U. S. House of Representatives
Washington, D. C. 20515

Dear Mr. Chairman:

This responds to your letters of November 25 and 30, 1981 concerning IAEA safeguards. In those letters, you raised several questions. Our responses follow:

As we have stated on a number of occasions, the NRC receives little specific information about the application of international safeguards in particular countries or at specific facilities. We do, however, receive substantial amounts of information of a more general nature, including some information on the application of safeguards at some types of facilities. When we do receive more specific information, it is usually classified and provided through secure channels. This information is usually controlled by the originating agency and thus is not releasable, even on a classified basis, by the NRC without the consent of the originator. We receive some classified information in the form of briefings, and thus do not always receive the source documents but are informed of the substance of the information.

Through these means we have been made aware of classified information that is applicable to several of your questions, much of which we are not authorized to disseminate further; therefore, we cannot fully respond to your questions. Where possible the answers to the questions in the body of your letter of November 25, and restated in your letter of November 30, are attached. However, the answers to the questions regarding the effectiveness of IAEA safeguards can more properly be addressed by agencies of the Executive Branch. We have discussed this matter with the appropriate agencies, and they have indicated a willingness to respond to any inquiries you may have. Our answer to the question in enclosure 2 of the November 25 letter will be forwarded to you under separate cover.

While our information on international safeguards implementation is rather limited, we do have enough information to be concerned that the IAEA safeguards system would not detect a diversion in at least some types of facilities. In any case, the Commission believes that safeguards have improved in recent years and that efforts should be made to continue this improvement as rapidly as possible. To the extent that our resources permit, the Commission is prepared to assist the Executive Branch in strengthening IAEA safeguards.

We have informed the appropriate Executive Branch agencies of this letter and their comments regarding factual accuracy and classification have been reflected. Commissioner Gilinsky adds that this includes the deletion of one question.

Commissioner Bradford did not participate in this letter. While he sympathizes with the Commission's desire to make as much information as possible available to the public, he feels that the questions cannot be adequately responded to in an unclassified letter. His responses will be transmitted in a separate classified document.

Sincerely,

Nunzio J Palladino

Nunzio J. Palladino

Enclosure:
Responses to Questions

cc: Representative James T. Broyhill

ANSWERS TO QUESTIONS IN CONGRESSMAN DINGELL'S LETTER AND ENCLOSURE OF NOVEMBER 25, 1981

Question: "Are international safeguards adequate to detect the diversion of nuclear equipment or material?"

Answer: As we noted above and in our letter of November 27th to you and other members of Congress, the Commission has concerns about the adequacy of IAEA safeguards. We cannot give you a meaningful overall judgment because such a judgment about adequacy would require information about specific materials, facilities, personnel, and equipment as well as the proliferation risks of particular nations. A more extensive discussion of this issue is provided below in response to your fifth question.

Although this question appears simple, it is, in fact, complex because the answer depends on underlying assumptions, standards, and expectations.

Commissioner Gilinsky's response is that international safeguards are not adequate.

Question: "Does the NRC explicitly consider the adequacy of international safeguards in export licensing decisions (not just physical security)? If not, why not?"

Answer: As stated in the Commission's testimony, given by Commissioner Gilinsky, before the Senate Foreign Relations Committee on December 2nd, the Commissioners "are unanimous that available information bearing on the adequacy of . . . safeguards in specific export cases must be taken into account." However, "the Commissioners are not of one mind on the legal basis for inquiring into the adequacy of IAEA safeguards . . . ."

Commissioner Ahearne's additional views relating to this question are attached.

Question: "Does the NRC believe that if a diversion were detected, such diversions would be reported promptly to the Board of Governors and the member states of the IAEA so that the member states would have time to react? Does the NRC have any evidence indicating reporting problems to the Board of Governors or from the IAEA to its member states?"

Answer: As our November 27th letter indicated, we are not confident that the member states of the IAEA would be notified of a diversion in a timely manner. This is not to suggest that we believe a clear diversion would be covered up by IAEA officials. However, most situations will be quite ambiguous even after investigation, and the IAEA process for determining whether or not a diversion has occurred may be time-consuming. The Commission has believed for several years that more information should be reported to the Board of Governors.

Question: "Please evaluate the overall effectiveness of international safeguards. In particular, evaluate the effectiveness of international safeguards as applied to:

(1) source material;

(2) fabrication of highly-enriched uranium and plutonium;

(3) research reactors;

(4) power reactors;

(5) spent fuel;

(6) transportation of each type of nuclear material;

(7) reprocessing of spent reactor fuel; and

(8) separated plutonium."

Answer: With respect to particular types of materials and facilities enumerated in your letter:

(1) IAEA safeguards under the Non-Proliferation Treaty are applied to source material when it is of a composition and purity suitable for fuel fabrication or enrichment, but not to uranium ore or "yellowcake." When source material is refined and converted to a form subject to safeguards, it is subject to the same safeguards applied to low-enriched uranium. Subject to the availability of resources, source material can be safeguarded effectively.

(2) Highly-enriched uranium and separated plutonium can be inspected. However, because they can be transformed readily into weapons, we cannot count reliably on inspection alone to provide warning of diversion of HEU and separated plutonium in time to prevent weapons assembly if the necessary preparatory work has been done.

Commissioner Ahearne notes that the necessary preparatory work includes design of the weapon and fabrication of all components of the device. These tasks are very difficult and require a group which is highly sophisticated technically.

(3) Research reactors range from very small reactors, sometimes fueled with low-enriched uranium, to very large reactors capable of producing substantial quantities of plutonium in a relatively short period of time, and sometimes fueled with HEU or with large amounts of natural uranium. The majority of research reactors are small and not difficult to safeguard effectively. Safeguards at large research reactors are often more complicated because these reactors can be used to make weapons quantities of plutonium and because research usually involves frequent activities in and around the core. The Department of Energy's Reduced Enrichment for Research and Test Reactors (RERTR) program is important in eliminating one of the two basic proliferation concerns associated with these large reactors, i.e., that of diverting fresh fuel.

(4) Most power reactors are either of two basic types: light water reactors that are refueled roughly once a year while shut down, and (usually) heavy water reactors that are refueled almost daily while operating. LWR's are among the most easily safeguarded of all nuclear facilities. On-line refueled reactors present technical safeguards problems that are more difficult to solve than for light water reactors. However, technical measures are being developed to solve these problems, although they may be costly and/or highly dependent on equipment reliability.

(5) Spent fuel stored as fuel elements can be accounted for item by item, if there is continuity of knowledge, and does not present particularly difficult safeguards problems.

(6) The transportation of nuclear material does not create any particular technical safeguards difficulties beyond those otherwise associated with the kind of material involved. The ability of the IAEA to account for nuclear material transferred from one country to another needs improvement. The IAEA recognizes this need and has recently held a consultants meeting on this matter.

(7) Inspection of large-scale reprocessing plants presents a number of particularly difficult technical problems. While progress is being made, it is clear that significant problems will remain for the foreseeable future. Because of the plutonium present in reprocessing plants, please also refer to our answer to (2) above.

(8) Please refer to our answer to (2) above.

Although you did not raise the question of enrichment plants, these raise difficult issues for effective safeguards. These are being addressed in an international study group.

Question: "Given the above evaluation, should the NRC continue to rely on the IAEA safeguards system in licensing exports from the U. S. of nuclear materials and equipment?"

Answer: We recognize the shortcomings of the IAEA system. However, the NRC has never placed sole reliance on the IAEA safeguards system in licensing nuclear exports. The NRC's evaluation of IAEA safeguards effectiveness, stated in the November 27th letter, raises questions for us about the exercise of our export licensing responsibilities. As that letter further states, the Commission is reviewing its responsibilities under the Atomic Energy Act of 1954, as amended, for the licensing of nuclear exports in light of our concerns, and we will inform you of our conclusions. However, as suggested by Commissioner Gilinsky in his response to a question during the December 3rd Senate Foreign Relations Committee hearings, we do not expect that there will be a change in export approvals for our principal nuclear trading partners.

Commissioner Ahearne's additional views relating to this question are attached.

Commissioner Ahearne provided the following additional views:

It should be recognized that the nature of NRC's assessment of safeguards for exports has involved substantial controversy. In part, the difficulty stems from lack of clear guidance from Congress, and in part, because a regulatory agency which is used to obtaining and assessing detailed information has difficulty in making subjective judgments based on sketchy information.

Prior to passage of the Nuclear Non-Proliferation Act, the Commission informed Congress that it had difficulty reaching conclusions on the adequacy of safeguards for exports:

> "The Commission wishes to reiterate that it does not receive sufficient country-specific safeguards information to allow it to make an independent assessment of the adequacy or effectiveness of safeguards implementation in a country for which an export license is being requested. It, therefore, is faced with making such licensing decisions on the basis of other factors noted previously and its general view of safeguards. The Commission's staff has noted its inability on the basis of available information to provide such independent safeguards assessments and has asked for Commission guidance as to the course it should follow in these circumstances." 1/

Although there was some discussion during debates on the NNPA, Congress provided no clear guidance. As Senator McClure put it, "The bill does require NRC to make their own assessment [of the adequacy of safeguards]. The question, I guess, boils down to what is an independent assessment." 2/ Senator Percy closed the primary discussion of this issue by stating: "[T]his legislation is not intended to prejudge the current debate as to the information which the United States should seek to obtain with respect to the adequacy of IAEA safeguards on U.S. exports or as to the roles which the various interested agencies should perform in the process." 3/

1/ Letters from NRC Chairman Hendrie to Senator Sparkman and Representative Zablocki (February 2, 1978).

2/ Congressional Record (Daily Edition) S.1464 (February 7, 1978).

3/ Id.

As we have told Congress, safeguards assessment continues to be a problem:

> "In general, as indicated in these documents, while both the Commission and the Executive Branch consider the effectiveness of international safeguards to be an important element of the export licensing process, the NRC staff continues to believe that [illegible] not currently receive sufficiently specific information to permit it to reach a conclusion as to the effectiveness of IAEA safeguards in countries receiving U.S. nuclear exports without some reliance on the Executive Branch and IAEA's own conclusions regarding safeguards." 4/

It is unlikely that the NRC and Executive Branch will be able to resolve the difficulties. Because of international sensitivities, there are clear constraints in obtaining detailed information about safeguards in other countries. This creates problems because of the regulatory nature of the NRC:

> "In reviewing domestic licenses, the NRC staff is able to obtain detailed information to evaluate. Based on this information, it is able to reach conclusions concerning the adequacy of safeguards at particular facilities. However, as mentioned previously, there is little specific information on international safeguards available to assess. Consequently, the NRC staff is unable to perform the types of reviews and reach the same types of conclusions in the international area that they do in the domestic area." 5/

There is little prospect that the situation will change because of the inherent nature of the problems.

These practical limitations have led to a difference of views within the NRC and between the NRC and the Executive Branch on the nature of the finding required under the safeguards criterion in Section 127 of the NNPA. This situation was described in a recent GAO report to Congress. 6/ It led GAO to recommend that Congress "clarify to what extent the effectiveness of international safeguards should be considered by the Nuclear Regulatory Commission in export licensing." 7/

4/ Letter from NRC Chairman Ahearne to Senator Glenn (March 7, 1980).

5/ Id.

6/ General Accounting Office, "The Nuclear Non-Proliferation Act of 1978 Should Be Selectively Modified," OCG-81-2 (May 21, 1981).

7/ Id. at xiii.

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August 13, 1982

Mr. Richard T. Kennedy
Under Secretary for Management
U.S. Department of State
Washington, D.C. 20520

Dear Mr. Kennedy:

We appreciated having Dr. Sessoms testify on the Department of State's safeguards research and development programs at the Subcommittee's hearing on August 3, 1982. Chairman Bouquard would like to supplement the record of the hearing with some additional questions regarding the programs. We appreciate your cooperation on this matter and we hope that this information can be provided by September 1, 1982.

We also request that the Subcommittee be provided with one copy of each unclassified report and publication on safeguards wholly or partially funded by the Department of State or its contractors, as well as a listing of all such documents, both classified and unclassified, commencing from the beginning of calendar year 1980. In addition, please place Dr. Harlan Watson of the Subcommittee staff on your mailing list to receive all unclassified safeguards documents in the future.

If you have any general questions regarding these requests, please contact me at 225-8056. If you have any questions regarding the specifics, please contact Dr. Harlan Watson of the Subcommittee staff at 225-3472.

Sincerely,

John V Dugan Jr/ms

JOHN V. DUGAN, JR., Staff Director
Subcommittee on Energy Research
and Production

JVD:Wjs
Enclosures

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
CHAIRMAN BOUQUARD'S QUESTIONS ON
TECHNICAL ASPECTS OF NUCLEAR NONPROLIFERATION: SAFEGUARDS
Hearing held August 3, 1982

1. Do present safeguards R&D programs cover all of the gaps in the present system that would have to be filled if plutonium has a commercial future?

2. It is noted that FY 1982 expenditures for POTAS are about $4 million. How is this funding broken down? What is the FY 1983 funding request, and how does it compare in detail with the FY 1982 funding?

3. What are the overall goals of the Department of State for safeguards technology? What is needed when?

4. Mention is made of the Javelin Cerenkov night viewing device, and that the characteristic glow associated with spent fuel becomes fainter as the fuel gets older. At what age would the glow no longer be detectable by present or improved inspection devices? In that event, what would be the risks of substitution of dummy spent fuel?

5. Details are given about U.S. cooperation with other countries on safeguarding of enrichment. Is there a comparable cooperation with other countries on safeguarding reprocessing plants and the separated plutonium?

6. Page 12 of the testimony says that in the long term "attention will have to be focused on ensuring that the IAEA has the tools at its disposal to safeguard the large bulk handling facilities that will be coming on line."

   a. What does this mean in terms of IAEA and U.S. goals for safeguards RD&D?
   b. Have these goals been established, and, if so, by whom?
   c. How widely accepted are they among the Agency, the U.S., and by other leading nuclear states?
   d. How does the plan for U.S. safeguards research support these goals, particularly for production and use of plutonium?

7. It is m, understanding that OMB holds that U.S. safeguards money provided to IAEA can go for R&D, but not for procurement of equipment. What is the Department's thinking on how funds for purchase of working equipment for the IAEA will be raised? Who will provide the money?

8. If you had within your power and authority to devise a different scheme or organizational format for conducting domestic and international safeguards research and development, how would you change the current situation?

DEPARTMENT OF STATE
Washington, D.C. 20520

SEP 13 1982

Dear Madame Chairman:

The Subcommittee's interest in the technical aspects of non-proliferation is greatly appreciated. We believe that the Hearings on August 3 and 4 contributed significantly to a better understanding of international safeguards as a cooperative verification measure and of the U.S. efforts to strengthen the IAEA's technical capability.

Answers to the questions raised by Dr. Dugan in his letter of August 13 to Mr. Kennedy are enclosed. We have arranged for the additional information requested by Dr. Dugan to be forwarded to him under separate cover. Also as he requested, we have arranged for copies of all future unclassified reports to be sent to Dr. Watson of the Subcommittee staff.

If you have any additional questions or request, please do not hesitate to call on us.

With cordial regards,

Sincerely,

Powell A. Moore

Powell A. Moore
Assistant Secretary for
Congressional Relations

Enclosure
As Stated

The Honorable
Marilyn L. Bouquard
Chairman, Subcommittee on Energy Research
and Production,
House of Representatives.

1. Q: Do present safeguards R&D programs cover all of the gaps in the present system that would have to be filled if plutonium has a commercial future?

A: Present safeguards R&D programs address all areas related to plutonium as it may be used in civil nuclear programs. This includes,

- Reprocessing plants
- Plutonium storage facilities
- Mixed oxide fuel fabrication plants
- Thermal reactors using plutonium fuels
- spent fuel storage facilities

2. Q: It is noted that FY 1982 expenditure for POTAS are about $4 million. How is this funding broken down? What is the FY 1983 funding request, and how does it compare in detail with the FY 1982 funding?

A: The funding for POTAS in FY 1982 is broken down into five major task areas. These are

- Measurement Technology
- Training
- System Studies
- Information Processing and Evaluation
- Containment and Surveillence

There is significant interaction among these different areas since implementation of instruments and techniques frequently are different aspects of a given technology development. In FY 1982 about half of the POTAS effort is in implementation. This trend will continue in FY 1983.

In FY 1982 the $4.1 million in POTAS funds is being used for 54 tasks as of May 1. (See Annex I) . This number has changed somewhat as cost free experts have been brought on board since this document was compiled. A detailed description of end level funding for each task is given in Annex II.

In FY 1983 we expect $4.35 million for POTAS. The allocation of funds will be similar to that in FY 1982 but some details will change as tasks are completed and new tasks are added.

The issue of "what is needed when" is addressed in the POTAS task approval process. The IAEA, through its internal management procedures, identifies tasks which it needs as a matter of priority. The USG Technical Support Coordinating Committee then reviews these task proposals to determine among other things, which are the highest priority items.

Annex I

Active Tasks:

Task Area A - Measurement Technology ....

A.47 - Prediction of Calorimeter Equilibrium.......................

A.56 - Measurement Procedures and Standard Reference Materials to Optimize Implementation of Resin Bead Techniques.........

A.59 - Air Shipment of Plutonium Samples to Facilitate International Safeguards.....................................

A.70 - Development of an Inspector Data Verification and Evaluation System for the Automated Electromanometer........

A.79 - Methods for Adapting K-Edge Densitometer and Gamma Spectrometer for IAEA Applications..........................

A.84 - Qualitative Verification Criteria - Material Authenticity...

A.90 - Access to U.S. Facilities and Calibration Standards.........

A.95 - Program for Implementing Use of HLNCC......................

A.96 - Program for Implementing Use of AWCC.....................

A.97 - Program for Implementing Use of Gamma and Neutron Chambers for Spent Fuel Measurements................................

A.98 - Program for Implementing Use of Portable Measurement Equipment to Verify UF_6 Mass Determination...................

A.99 - Special Measuring Heads for Neutron Coincidence Counting of Plutonium...

A.100 - Senior NDA Expert for Coordination of Implementation Plans..

A.101 - NDA/Instruction and Procedures Expert.......................

A.102 - Cost-Free Expert to Assist in Improving Effectiveness and Efficiency of Safeguards....................................

A.103 - Program for Implementing Use of Active Neutron Coincidence Collar...

A.104 - Program for Implementing Use of the LLNL Microprocessor for Pu Isotopic Analysis..................................

A.105 - Program for Implemeting Use of the Portable LANL-MCA ....

A.106 - Management of Technical Support ....

Task Area B - Training ....

B.15 - Training for Nuclear Fuel Plant Processes ....
B.19 - IAEA Participation in U.S.-Sponsored Training Courses ......
B.24 - Cost-Free Training Expert ....
B.25 - Cost-Free Training Expert ....
B.26 - Cost-Free Training Expert ....
B.27 - Cost-Free Training Expert ....
B.28 - Facility Familiarization Information ....
B.29 - In-Field Training for Verification of HEU ....
B.30 - In-Field Training for Verification of Pu ....

Task Area C - System Studies ....

C.22 - Evaluation and Quantification of Safeguards Effectiveness.....
C.28 - Models for Safeguarding Generic Types of Facilities...........
C.31 - Development of Guidelines for Practical Implementation of the Elements of SSAC.......................................
C.46 - Computerization of PWR Anomaly Assessment Modules.............
C.47 - Develop Safeguards Approach for a Medium Sized Reprocessing Plant by Application of Safeguards Effectiveness Assessment Methodology..
C.48 - Application of Safeguards Effectiveness Assessment Methodology for Mixed-Oxide Fuel Fabrication Facilities..................
C.49 - Coordination and Implementation of Guidelines for Practical Implementation of the Elements of SSAC.......................
C.50 - Diversion Assumptions for High Power Research Reactors........
C.51 - Use of Safeguards Effectiveness Methodology Data..............

Task Area D - Information Processing and Evaluation..................

D.26 - Software Support for the Field Computer System................
D.29 - Cost-Free Experts - Analysts/Programmers (3)..................
D.35 - Establish ICT Procedures for Use by Inspectors at Reprocessing Facilities Under Safeguards.................................
D.37 - Expert for Development of Methods for Evaluation of Inspection Data...
D.38 - Expert for Developing Methods of Evaluation and Processing of Inspection Data...
D.39 - Senior Expert in Evaluation of Safeguards.....................
D.40 - Cost-Free Expert Analyst/Programmer...........................
D.41 - Expert for Developing Methods for Evaluation and Processing of Inspection Data...
D.42 - Cost-Free Expert - Documentation and Training Officer.........
D.43 - Expert for Development of Safeguards Evaluation Methodologies and Procedures..

Task Area E - Containment and Surveillance............................

E.40 - Supply Portable Battery-Powered TV Surveillance Systems.......
E.45 - Integrated Monitoring System for Light Water Reactor Spent Fuel Storage Areas..
E.46 - Cassette-Type Video Tape Recorder Evaluation..................
E.50 - Improved Cerenkov Measurement System.........................
E.54 - Program for Implementation of the Task E.25 Advanced TV Surveillance System...
E.55 - Evaluation of RECOVER Monitoring System......................
E.56 - Professional Experienced in Remote Monitoring, Data Transmission and Surveillance Techniques..........................

3. Q: What are the overall goals of the Department of State for safeguards technology? What is needed when?

A: IAEA safeguards ascertain that there has not been a diversion of nuclear material by verifying the findings of the system of accounting and control for nuclear materials of individual states. This verification is accomplished by independently sampling and measuring nuclear materials, and by using containment/surveillance techniques to assure the integrity of those measurements over time. To perform these functions the IAEA needs measurement (especially non-destructive assay) equipment and containment/surveillance equipment that is accurate, reliable, and easy to use under difficult field conditions. The IAEA also needs the procedures and training to use individual pieces of equipment, and the systems studies and methodologies to integrate individual types of equipment and procedures into effective and efficient safeguards approaches.

It is the goal of the Department of State, and the objective of the Program of Technical Assistance to Safeguards, to participate with other countries to assure that the IAEA has the needed equipment, procedures, and training materials, and the system studies and methodologies necessary for their integrated use, and to support the transfer of this technology to the IAEA for routine use in international safeguards.

Q. Mention is made of the Javelin Cerenkov night viewing device, and that the characteristic glow associated with spent fuel become fainter as the fuel gets older. At what age would the glow no longer be detectable by present or improved inspection devices? In that event, what would be the risks of substitution of dummy spent fuel?

A: The initial intensity of the Cerenkov glow is a function of the burn-up of the fuel. Higher burn-up fuel give more light. After a few years in the fuel pond the glow of the spent fuel reaches a level beyond which the decrease is very slow. The Javelin Cerenkov device has been tested on very old (in the pond longer than 10 years) spent fuel and fuel of various burn-ups. No difficulty was found in seeing the characteristic glow. It is unlikely that, for the forseeable future, there will be any problem detecting the Cerenkov glow from spent reactor fuel that will be under safeguards.

5. Q: Details are given about U.S. cooperation with other countries on safeguarding of enrichment. Is there a comparable cooperation with other countries on safeguarding reprocessing plants and the separated plutonium?

A: An exercise for reprocessing plants comparable to the Hexapartite Safeguards Project for enrichment plants was the Tokai Advanced Safeguards Technology Exercise (TASTEX). This two-year developments effort was centered at the reprocessing plant at Tokai Mura, Japan. The participants were Japan, France, the IAEA, and the U.S. Another effort was the work of the International Working Group on Reprocessing Plant Safeguards. This was a large multinational effort under IAEA auspices. The working group's report has been submitted to the Director General for his use in developing safeguards approches for reprocessing plants.

Assessment of safeguards related to separated plutonium has taken place as part of the international plutonium storage discussions. Some 30 countries have been involved in these discussions for several years. The main deliberative body has been a group of experts which is to report to the IAEA Director General its views on the structure of an International Plutonium Storage (IPS) System. Under its aegis a working group on IPS and safeguards outlined the relationship between possible IPS schemes and current IAEA safeguards. The final report of this working group has been submitted to its parent body for incorporation into the report to the Director General on the status of IPS discussions.

6. Q: Page 12 of the testimony says that in the long term "attention will have to be focused on ensuring that the IAEA has the tools as its disposal to safeguard the large bulk handling facilities that will be coming on line."

a. What does this mean in terms of IAEA and U.S. goals for safeguards RD&D?

A: The safeguards goals for large bulk handling facilities such as large reprocessing and MOX fuel fabrication plants are the same as for smaller facilities currently in existence. However, meeting those goals will require the development of new instruments and techniques. We are actively working with other interested countries to ensure that these are available on a timely basis. This includes near-real time accounting systems and extended containment and surveillance schemes involving advanced types of cameras.

IAEA requests for assistance, and U.S. efforts to satisfy those requests, are based on these on-going efforts.

6b. Q: Have these goals been established, and if so, by whom?

A: The safeguards goals are based on recommendations by the IAEA's Safeguards Advisory Group (SAGSI). This is a senior level group appointed by the Director General to advise him on safeguards issues. The U.S. and other key IAEA member states have representatives on SAGSI. The IAEA uses these goals for inspection planning and evaluation purposes.

6c. Q: How widely accepted are they among the Agency, the U.S., and by other leading nuclear states?

A: These goals are accepted by the IAEA, the U.S. Government, and other IAEA member states for use by the IAEA. The use of these goals, which have been submitted in documents by the Secretariat to the Board of Governors, has never been challenged by the Board.

6d. Q: How does the plan for U.S. safeguards research support these goals, particularly for production and use of plutonium?

A: The details of the U.S. support program given in answer to question 2 indicate that our efforts in the R&D area in support of IAEA safeguards goals cover all issues of concern. This includes work on most aspects of potential plutonium fuel cycles.

Our efforts in the areas of non-destructive assay instrument development (especially neutron and gamma ray techniques); system studies related to safeguards approaches (for MOX fuel fabrication plants, reprocessing plants, breeder reactors and thermal recyle in light water reactors); containment and surveillance (especially advanced camera systems), all have a direct relevence to fuel cycles using plutonium. In addition we are working with the IAEA to upgrade the skills of the inspectorate. This is directly in support of Agency goals in the safeguards area.

7. Q: It is my understanding that OMB holds that U.S. safeguards money provided to IAEA can go for R&D, but not for procurement of equipment. What is the Department's thinking on how funds for purchase of working equipment for the IAEA will be raised? Who will provide the money?

A: Equipment which has been accepted for routine use in IAEA safeguards should be procured through the IAEA budget. The regular budget of the IAEA, funded by annual assessments on member states (the U.S. pays 25%) includes about $1.6 million for safeguards equipment procurement in 1982 and a projected $4 million in the preliminary 1983 budget.

Funds allocated under the Program of Technical Assistance to Safeguards (POTAS) are needed for research, development, test, and evaluation of safeguards equipment and other safeguards technology, and for cost-free experts and training to transfer this technology to the IAEA. Prototype equipment for field testing and evaluation is procured for the IAEA through POTAS. On occasion the IAEA faces an unusual or unique safeguards situation for which a special piece of equipment is required. In such cases POTAS funds are used to develop this equipment and to deliver to the IAEA one or several units for field testing.

8. Q: If you had within your power and authority to devise a different scheme or organizational format for conducting domestic and international safeguards research and development, how would you change the current situation?

A: U.S. research and development regarding technology for international safeguards is directed by a series of inter-agency groups. Policy level guidance is provided by the Interagency Steering Group on IAEA Safeguards (ISG). Overall coordination of U.S. activities to improve IAEA safeguards is the responsibility of the Action Plan Working Group, which reports to the ISG. Coordination and direction of the U.S. technical support program is the responsibility of the Technical Support Coordinating Committee which also reports to the ISG. This structure appears to work well in responding both to the long-term needs of the IAEA and to short-term or immediate problems as these are identified.

As more countries follow U.S. leadership and initiate their own programs of technical support to IAEA safeguards, there is a growing need for formal procedures to coordinate among these programs. This need is recognized by the IAEA and the countries involved. One informal meeting of the program coordinators from different countries and the IAEA took place recently in Washington. In November the IAEA will hold a week long meeting to establish the needed formal coordinating mechanisms. The State Department has also conducted bilateral discussions with a number of countries to coordinate not only technical support, but also political and other activities in support of IAEA safeguards.

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August 13, 1982

Mr. Eugene V. Rostow, Director
U.S. Arms Control and Disarmament Agency
Washington, D.C. 20230

Dear Mr. Rostow:

We appreciated having Dr. Menzel testify on the Arms Control and Disarmament Agency's safeguards research and development programs at the Subcommittee's hearing on August 3, 1982. Chairman Bouquard would like to supplement the record of the hearing with some additional questions regarding the programs. We appreciate your cooperation on this matter and we hope that this information can be provided by September 1, 1982.

We also request that the Subcommittee be provided with one copy of each unclassified report and publication on safeguards wholly or partially funded by the Arms Control and Disarmament Agency or its contractors, as well as a listing of all such documents, both classified and unclassified, commencing from the beginning of calendar year 1980. In addition, please place Dr. Harlan Watson of the Subcommittee staff on your mailing list to receive all unclassified safeguards documents in the future.

If you have any general questions regarding these requests, please contact me at 225-8056. If you have any questions regarding the specifics, please contact Dr. Harlan Watson of the Subcommittee staff at 225-3472.

Sincerely,

John V. Dugan/jws

JOHN V. DUGAN, JR., Staff Director
Subcommittee on Energy Research
and Production

JVD:Wjs
Enclosures

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
CHAIRMAN BOUQUARD'S QUESTIONS ON
TECHNICAL ASPECTS OF NUCLEAR NONPROLIFERATION: SAFEGUARDS

Hearing held August 3, 1982

1. Table II for ACDA's budget shows no funds for instruments and methods and almost a halving of funds for R&D between 1981 and 1982. What has ACDA cut out to accommodate these reductions? In particular, how much of the work cut out was for plutonium fuel cycle safeguards?

2. Can it really be said that ACDA's safeguards program is effective in light of the budget cuts shown in Table II? Also, how effective is it for preparing the way for breeding fuel cycles and plutonium recycle?

3. What are ACDA's plans in safeguards for FY 1983? What is ACDA's FY 1983 budget request?

4. It is stated that ACDA's professionals keep abreast of the latest developments in the U.S. and abroad. This would imply ACDA no longer views itself as a leader, but rather as a monitor, an observer, or a second class body. Why does not ACDA say it takes the lead?

5. The RECOVER project is highlighted as taking a "considerable fraction" of ACDA's research resources for the last four years.

    a. What application could this have to plutonium fuel cycles?
    b. How much could it reduce fears of diversion without timely warning?
    c. Could the RECOVER communications systems be used to give IAEA inspectors a secure, independent channel of personal communication with the Agency?

6. The testimony notes that ACDA contracted with Exxon to document in detail the IAEA safeguards inspection activities being carried out in the Exxon plant. Is NRC doing anything comparable, since NRC personnel accompany the IAEA inspectors, and if so, how is ACDA coordinating with the NRC? What is the NRC doing that ACDA is not, and vice versa?

7. Exactly who has the lead responsibility for safeguards R&D and do the various coordinating groups have any authority other than to try to reach a consensus?

8. If you had it within your power and authority to devise a different scheme or organizational format for conducting safeguards research and development, how would you change the current situation?

UNITED STATES ARMS CONTROL AND DISARMAMENT AGENCY
Washington, D.C. 20451

September 3, 1982

Dear Mr. Dugan:

The Subcommittee's interest in the technical aspects of non-proliferation is greatly appreciated. We believe that the Hearings which Representative Bouquard so ably chaired on August 3 and 4 contributed significantly to a better understanding of international safeguards as a cooperative verification measure and of the U.S. efforts to strengthen the IAEA's technical capability.

The additional information you requested in your letter of August 13 to Mr. Rostow is enclosed. A number of unclassified safeguards reports for contracts initiated since FY-1980 is being sent to you under separate cover. As you requested, we will send copies of all future reports to Dr. Watson of the Subcommittee staff.

If you have any additional questions or requests, please do not hesitate to call on us.

Sincerely,

Thomas Graham

Thomas Graham, Jr.
Director, Office of
Congressional Relations
and Public Affairs

Enclosure As stated

Dr. John V. Dugan, Jr.
Staff Director
Subcommittee on Energy
Research and Production

Question 1

Table II for ACDA's budget shows no funds for instruments and methods and almost a halving of funds for R&D between 1981 and 1982. What has ACDA cut out to accommodate these reductions? In particular, how much of the work cut out was for plutonium fuel cycle safeguards?

As mentioned in ACDA's statement, the allocation of the safeguards funds among the four project areas varies from year to year depending inter alia on the nature of projects being sponsored by others. Table V (Part III) of the statement shows that, prior to FY-1981, ACDA sponsored projects for specific aspects of optical surveillance and seal development. By FY-1981, the programs on optical surveillance and seal development being conducted under POTAS and under DOE funding had gained sufficient momentum to obviate ACDA's continued efforts in this area. Thus, since in our view new instruments and methods for IAEA safeguards were sufficiently covered by other US programs beginning in FY-1981, ACDA did not need to cut out anything from its program or sponsor any work in this project area.

With respect to the fact that ACDA's funds of external research for international safeguards planned for FY-1982 is about 60% of those for FY-1981 must be seen as the result of the general budget tightening, the increasing impact of the POTAS program and, to a lesser extent, the allocation of research funds within ACDA. On the last point, due to program adjustments, it is expected that ACDA will be able to obligate sufficient funds for safeguards research in FY-1982 to constitute as much as 70% of those obligated in FY-1981.

Question 2

Can it really be said that ACDA's safeguards program is effective in light of the budget cuts shown in Table II? Also, how effective is it for preparing the way for breeding fuel cycles and plutonium recycle?

We believe ACDA continues to have a very effective external research program. As stated above, it is expected that ACDA will be able to obligate in FY-1982 as much as 70% of the research funds obligated in FY-1981 for international safeguards. In a year of tight budgets, this signifies the importance ACDA places on IAEA safeguards as a vital measure for cooperative verification of the peaceful utilization of nuclear energy.

The projects ACDA is funding in FY-1982 are complementary to those sponsored by other agencies. They cover a wide spectrum of needs as we see them. In terms of preparing the way for breeding fuel cycles and plutonium recycle, we feel that the projects in system development and remote verification will in time make a significant contribution.

Question 3

What are ACDA's plans in safeguards for FY 1983? What is ACDA's FY 1983 budget request?

For FY-83, ACDA's budget submission to Congress includes $5,952,000 for external research. However, $4,800,000 of this amount are connected with the possibility of funding the program on Reduced Enrichment for Research and Test Reactors (RERTR) in the budget of ACDA instead of DOE. This leaves $1,152,000 for the continuing research program in FY-83, with $310,000 of that allocated for safeguards. Although this is substantially less than the amount for FY-82, it is anticipated that the slow start in the current fiscal year and the consequent initiation of many of the projects just prior to FY-83 will permit us to bridge the gap until early FY-84. These factors have entered into the planning for ACDA's FY-83 budget.

Question 4

It is stated that ACDA's professionals keep abreast of the latest developments in the U.S. and abroad. This would imply ACDA no longer views itself as a leader, but rather as a monitor, an observer, or a second class body. Why does not ACDA say it takes the lead?

International safeguards is an evolving system, technically and politically complex. Much remains to be done as the nuclear fuel cycle expands. Significant contributions are being made by many sectors of the U.S. government, by the U.S. nuclear industry, and by the governments of several foreign countries. And ACDA continues to be able to contribute to this total effort from its unique perspective as a small agency with access at high levels of the U.S. government, with its own external research program, and with a cadre of physical science and foreign affairs officers working hand-in-hand.

Where we have the expertise or we start a particular initiative, we often do take the lead; for example, ACDA provides the U.S. contact point for the multilateral discussions on enrichment plant safeguards, heads the U.S. delegation for meetings on international plutonium storage, furnishes the U.S. expert for the IAEA Director General's twelve-member Standing Advisory Group on Safeguards Implementation (SAGSI), and led the U.S. effort in the now concluded international Working Group on Reprocessing Plant Safeguards. All of these efforts are closely coordinated with and actively supported by State, DOE, NRC and staff at the national laboratories. In efforts led by State or other Washington agencies, we in turn are consulted and, quite often, are able to make significant contributions.

Question 5

The RECOVER project is highlighted as taking a "considerable fraction" of ACDA's research resources for the last four years.

a. What application could this have to plutonium fuel cycles?
b. How much could it reduce fears of diversion without timely warning?
c. Could the RECOVER communications systems be used to give IAEA inspectors a secure, independent channel of personal communication with the Agency?

The objective of the RECOVER program is the improvement of international safeguards through the remote monitoring via the commercial international telephone network of safeguards sensors and the secure transmission of safeguards data to central or local IAEA safeguards offices. The potential benefits are in terms of (a) improved effectiveness through the provision of more complete and more timely safeguards data contributing to more reliable and timely decisions by the IAEA and (b) increased efficiency in the use of IAEA inspector resources by reducing the effort needed for routine monitoring of safeguards sensors. In regard to the specific questions:

a. As a recent study by DOE concluded ("An Evaluation of a Remote Continual Verification System, RECOVER, for International Safeguards" by E.V. Weinstock and J.B. Sanborn, DOE Contract No. DE-AC02-76CH00016), RECOVER could be beneficial and cost-effective in the safeguarding of facilities like, inter alia, fast critical assemblies used for breeder development and inactive stores of plutonium. In addition, it is expected that future, large plutonium handling facilities will incorporate remote monitoring on a inter-and intra-facility scale.

b. Utilization by the IAEA of a capability for the remote continual monitoring of safeguards devices and the secure, timely transmission of safeguards-relevant data to regional IAEA centers and/or IAEA headquarters in Vienna should contribute significantly to increased confidence that nuclear energy is used only for peaceful purposes and that the assurances provided by the IAEA are backed up by a effective and efficient system of cooperative verification.

c. Yes, it has recently been demonstrated that the RECOVER hardware can be used to provide IAEA inspectors in the field with a secure communication link to IAEA headquarters for the timely transmission of summary inspection reports.

Question 6

The testimony notes that ACDA contracted with Exxon to document in detail the IAEA safeguards inspection activities being carried out in the Exxon plant. Is NRC doing anything comparable, since NRC personnel accompany the IAEA inspectors, and if so, how is ACDA coordinating with the NRC? What is the NRC doing that ACDA is not, and vice versa?

We understand that NRC is currently not doing anything comparable at Exxon. The reports resulting from ACDA's contract with Exxon are being provided promptly to NRC.

Question 7

Exactly who has the lead responsibility for safeguards R&D and do the various coordinating groups have any authority other than to try to reach a consensus?

For R&D in international safeguards, ACDA, State, DOE and NRC contribute to the total U.S. effort in support of strengthening IAEA safeguards in accordance with their respective mandates and resources. Several opportunities for such coordination routinely arise throughout the year. For example, during the budget review process Executive branch agencies review their research activities in safeguards to assure a concerted effort to support this Administration's policy of improving the international safeguards regime.

Question 8

If you had it within your power and authority to devise a different scheme or organizational format for conducting safeguards research and development, how would you change the current situation?

Within the organizational framework of the Executive Branch, the established system of coordination and decision making provides for the effective implementation of the President's nonproliferation policy. And, as a part of that overall system the current organizational format for conducting safeguards R&D works well and has made significant contributions to international safeguards. There are many examples to show that the ability of ACDA to use its external research funds to explore innovative safeguards approaches or the feasibility of new technical concepts has served safeguards well.

TECHNICAL ASPECTS OF NUCLEAR NONPROLIFERATION: SAFEGUARDS

WEDNESDAY, AUGUST 4, 1982

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Research and Production,
Washington, D.C.

The subcommittee met, pursuant to recess, at 9:35 a.m., in room 2318, Rayburn House Office Building, Hon. Marilyn L. Bouquard (chairman of the subcommittee) presiding.

Present: Representatives Bouquard, Lujan, Lowery, and Hollenbeck.

Mrs. Bouquard. The subcommittee will come to order.

I ask unanimous consent at this time, pursuant to House rules, that television and other recording of today's hearing be permitted. I hear no objection. So ordered.

Good morning, ladies and gentlemen. Today the Subcommittee on Energy Research and Production will continue its hearings on safeguards research and development.

As I noted in my opening remarks yesterday, safeguards are a vital element of our overall nuclear nonproliferation policy. Effective safeguards are widely perceived as essential to the health and the vitality of international nuclear cooperation and commerce.

Today we will be receiving testimony from witnesses from the national laboratories, industry, and the American Nuclear Society. Appearing on our first panel today will be Dr. Herbert Kouts of Brookhaven National Laboratory, Dr. James Shipley of Los Alamos National Laboratory, and Dr. William Myre of Sandia National Laboratories. These gentlemen will be telling us about the ongoing R&D work at their respective laboratories.

Our second panel will be comprised of two gentlemen from private industry: Dr. James Buckham, who is president of Allied-General Nuclear Services, and Dr. Roy Nilson of Exxon Nuclear Co. Dr. Buckham, who will be accompanied by Mr. Karl Bambas, will describe the safeguards development work which has been conducted at the Barnwell nuclear fuel plant. Dr. Nilson will be telling us about Exxon's experience with IAEA safeguards, since Exxon's Richland facility was chosen by the IAEA in early 1981 as the first U.S. bulk-handling facility to come under IAEA safeguards.

Finally, in this morning's hearing we will be receiving testimony from Mr. Manning Muntzing, who will be appearing in his capacity as the new president of the American Nuclear Society. We do want to congratulate him on his election as the new ANS president. We

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hope to hear from him not only on the ANS position with respect to safeguards but we also intent to draw on his extensive background on the subject from his days at the Atomic Energy Commission and the Nuclear Regulatory Commission.

I do want to welcome all of you to today's hearings, and I am looking forward to our testimony.

Dr. Kouts, you may proceed with your testimony, followed by Dr. Myre and then Dr. Shipley. Questions will follow all your presentations.

[A biographical sketch of Dr. Kouts follows:]

DR. HERBERT KOUTS

Dr. Herbert Kouts was born in Bisbee, Arizona, and attended schools in Arizona, Texas, California and Louisiana. He is a graduate of Louisiana State University, and has a Ph.D. in physics from Princeton University.

Dr. Kouts is Chairman of the Department of Nuclear Energy at Brookhaven National Laboratory, on Long Island, New York. He has been at Brookhaven since 1950. conducting research in reactor shielding, reactor physics, reactor safety, nuclear materials safeguards, and related fields. He is a former member and chairman of the Advisory Committee on Reactor Safeguards. He organized the NRC's current research program in 1973, and directed it until 1976 when he returned to Brookhaven. He received the Atomic Energy Commission's E.O. Lawrence Award in 1963, and its Distinguished Service Award in 1974. He received the Nuclear Regulatory Commission's Distinguished Service Award in 1976. He was a member of the NRC's Risk Assessment Review Group (otherwise known as the Lewis Committee) and the Reactor Safety Research Review Group formed to advise the President's Nuclear Safety Oversight Committee.

Dr. Kouts is a member of the National Academy of Engineering.

STATEMENT OF DR. HERBERT J. C. KOUTS, CHAIRMAN, DEPARTMENT OF NUCLEAR ENGINEERING, BROOKHAVEN NATIONAL LABORATORY

Dr. KOUTS. It is a distinct pleasure to have this opportunity to discuss safeguards and nonproliferation programs before this subcommittee today.

My name is Herbert Kouts. I am chairman of the Department of Nuclear Energy at Brookhaven National Laboratory. Most of the activities of our department are related to the safety of nuclear powerplants but we do conduct programs in a number of other nuclear power-related subjects. Among these is the field of safeguards as applied to fissile material.

We have had a strong program in safeguards since 1968, when the old Atomic Energy Commission asked us to form a technical support organization which would serve as a close-coupled advisory body that could review AEC programs and recommend means of improving them. The Technical Support Organization, or TSO, still works closely with our Office of Safeguards and Security of the Department of Energy to provide technical assistance that rests on a long history of detailed involvement of Brookhaven in the nuclear fuel cycle.

Because the TSO is asked to advise the Department of Energy on technical requirements, it does not generally engage in DOE's programs of research on hardware. That is, it does not do research and development on measurement of fissile material, on physical protection methods, or on surveillance. The TSO becomes involved in using and applying the products developed by other laboratories but it does not often make new ones. There are some exceptions.

I should add that the TSO is not only called on by the Department of Energy for assistance, it also responds to needs by other Government agencies such as the Nuclear Regulatory Commission, the Department of State, and the Arms Control and Disarmament Agency. I list in my prepared report a number of representative tasks that the TSO has undertaken over the years, and I will just go quickly over the highlights of some of those which are listed.

In 1975 the TSO assisted the new Nuclear Regulatory Commission in performing the special studies that were required by the Energy Reorganization Act of 1974 and subsequently in developing more reliable domestic safeguards strategies for the back end of the fuel cycle. The TSO has been heavily involved in application of safeguards by the IAEA to U.S. facilities under the Presidential offer, and I describe some of these activities.

The TSO has played an important role, together with Union Carbide/Oak Ridge, the Los Alamos and the Sandia Laboratories, in developing and evaluating alternate inspection strategies for uranium enrichment plants. Presently the TSO provides assistance to the U.S. delegation on the Hexapartite Enrichment Plant Safeguards Group, which consists of the United States, the United Kingdom, the Netherlands, West Germany, Japan, Australia, EURATOM, and IAEA, which is attempting to develop international agreements on safeguards for such facilities. A related TSO assignment has been to study the features of the three alternate advanced-enrichment techniques, those aspects which would affect the application of international safeguards.

For many years the TSO has assisted the Atomic Energy Commission, then ERDA, and then the Department of Energy in evaluating the safeguards at Government-owned facilities and in designing and implementing more effective safeguards methods and techniques. Recently they have been involved in studying the potential consequences of theft of nuclear materials, sabotage of nuclear facilities, and have been studying legal matters affecting the response of DOE security forces, human factors that may contribute to improved domestic safeguards, and assistance in updating the environmental impact statement on the liquid metal fast breeder reactor and the environmental report on the Clinch River breeder. These are a few of a great many activities TSO has been involved in.

At present the staff of TSO consists of about 20 individuals with highly varied backgrounds and skills. The annual budget from all sources is about $1.9 million. The TSO specializes, when necessary, in fast response problem solving, and this is often necessary.

Since 1976 Brookhaven has maintained another safeguards group independent from the technical support organization. This is the International Safeguards Project Office, or ISPO, which administers for the Department of State the U.S. program of special technical assistance, called POTAS, in safeguards to the International Atomic Energy Agency. I believe you heard something about this program yesterday. This program was initiated through a clause in the State Department's fiscal year 1975 funding legislation establishing a 5-year program at $1 million per year to help IAEA to satisfy urgent needs which could not be covered by the regular budget.

In 1976, because of its long and deep involvement in many aspects of IAEA safeguards, Brookhaven was asked to form a new group to administer this program. The program has been such a success and has been so important in helping IAEA to build capability for its difficult task that the level of funding is now about $4 to $5 million a year and the duration has been extended. The total expenditures under the POTAS program are now about $27 million. This technical assistance program has contributed significantly to IAEA safeguards. Similar programs have since been instituted by Canada, the United Kingdom, the Federal Republic of Germany, Japan, and Australia, and others are on the way. The other programs now add up in dollars to a total magnitude approximately equal to that of POTAS.

ISPO formally receives its directives from the Office of Safeguards and Security at the Department of Energy. Oversight over the POTAS program is maintained by an interagency technical support coordinating committee which is chaired by the Department of State and includes representatives of the Department of Energy, the Nuclear Regulatory Commission, and the Arms Control and Disarmament Agency. This committee meets monthly.

ISPO consists of a staff of seven people, of whom five are scientific and technical and who have extensive experience in IAEA activities. One of the five is always in residence in Vienna, where IAEA is situated, and in fact the Vienna resident of ISPO functions as a de facto member of the U.S. mission staff to IAEA. The position of Vienna representative is rotated among the ISPO staff on an annual basis.

Brookhaven maintains a bank account for POTAS in New York which is drawn on directly by IAEA, with them writing the checks, in paying for approved out-of-pocket costs of the U.S. assistance program. These costs include, for example, the salaries and expenses of numerous technical experts who are supplied by the U.S. program and who formally are members of the IAEA's safeguards staff.

The program consists of tasks that satisfy specific request made formally by the IAEA, and I describe in my paper the long process of review of the tasks as they are requested and the method of approval of them, and the methods by which they are put into effect.

Other features of ISPO activities assure proper liaison with all the elements involved in the support operation. Formal meetings with IAEA are held every 6 months to review progress, discuss forthcoming requirements, and to settle problems. The ISPO staff member resident in Vienna holds discussions almost daily with IAEA staff and his associates back at Brookhaven. Each DOE laboratory participating in the POTAS program has a program coordinator. Program coordinators meet approximately twice a year at successive laboratory sites to review their programs.

POTAS has so far included 309 tasks. Of these, 220 have been complete and 51 are now active; 38 have been deferred or canceled for various reasons.

ISPO has also been used by the Government for other aspects of international safeguards. It managed the U.S. financial contribution to defray IAEA costs under the international fuel cycle evaluation program. ISPO also managed the recent joint United States-

Japanese program of experiments at the Tokai Mura spent fuel reprocessing pilot plant. This program is formally named the "Tokai Advanced Safeguards Technology Exercise," or TASTEX. ISPO also assists in recruiting qualified U.S. nationals to fill vacancies in the IAEA's regular safeguards staff.

I have listed a number of specific accomplishments of the ISPO program and I will skim over some of these. More than 40 items of equipment of 18 different types have been given to IAEA for test and evaluation and use in safeguards under nonproliferation. About 80 man-years of cost-free expert assistance have been provided the IAEA through skilled scientists and engineers who have been placed on the IAEA staff at U.S. expense. The information system used by IAEA to keep track of fissile material has been improved substantially through U.S. efforts. IAEA's inspection personnel have been introduced to difficult problems they will face in the future through their carrying out exercises at large U.S. plants, plants that are built and operating on scales that IAEA will later meet in other countries where they apply safeguards under NPT, and the U.S. has been extremely effective in supplying sealing methods which are used by the agency in its application of safeguards.

These are only a few of the great many ways that the POTAS program has been called on to help to improve IAEA safeguards. We have been assured a number of times by the Director-General of IAEA and the Deputy Director-General for Safeguards and Nonproliferation that POTAS has contributed significantly to the effectiveness of IAEA in its nonproliferation activities.

In all of the preceding, Madam Chairman, I think I have painted a picture which shows extensive coordination and cooperation among many elements involved in safeguards systems. I would now like to comment briefly on the adequacy of equipment used for nondestructive assay of fissile material and for containment and surveillance domestically and by the International Atomic Energy Agency.

My first comment is that the equipment best suited to the job is somewhat different in the two cases, since the missions of domestic and international safeguards are different, and then I discuss domestic safeguards and some of the requirements there and point out that the IAEA's methods generally lack the physical protection aspect which is important in domestic safeguards because international bodies such as the IAEA do not have the sovereignty necessary to conduct or control police methods. IAEA is restricted by governing agreements to verification of accounting data.

I know of only two departures from a really strict interpretation of that limit. The first is a requirement by the IAEA that physical protection be included in the State's system of safeguards, and an excellent IAEA guide has been issued defining typical features of the physical protection system that a State should maintain for this purpose. Second, there has been support which is substantial but not universal for an IAEA ability to apply continuous presence or resident inspection to make sure that accounting data are complete in such vital areas as isotope separation or spent fuel reprocessing.

There is a broad overlap of domestic and international requirements only in respect to methods of measurement of amount and composition of fissile material, especially the nondestructive methods. In nondestructive methodology we are always limited by a number of considerations. Nature restricts the possibilities of the methods that one might try to use. Practical considerations limit the methods that can reasonably be used. For instance, the IAEA especially needs instruments that are easily transportable into hostile climates and that can be used reliably even where such technical problems exist as abnormal line voltages and uncertain repair capabilities.

I do believe that the Department of Energy's development program and the POTAS program are providing the domestic and international safeguards systems with nondestructive assay equipment which is about as good as the current limits of technology permit. As technology improves it is quickly taken advantage of by the program, and the same thing is true of surveillance equipment being furnished the IAEA under the POTAS program, especially automated television recording equipment.

I do believe that there are still some definite technical requirements for IAEA safeguards if the nonproliferation objectives are to be met. First, equipment of the kind the POTAS program has been supplying must reach a state of common use by the IAEA inspection staff. So far, the movement from test to evaluation to application has been too slow. The problem is recognized and has been discussed with IAEA. Improvement of implementation is the present prime objective of the POTAS program. Solution of this problem is difficult but, with the cooperation of the agency, I am sure we will succeed.

Second, the long-term plan for procurement of equipment by IAEA must be carried through. Dr. William Higinbotham of the Technical Support Organization has identified a requirement for about $20 million of equipment over the next 5 years to be added to agency capability. This requirement has now been incorporated into the IAEA's operating budget projections but only prototypes exist for many of the items needed and commercial sources do not exist for many other kinds. A determined effort is needed to ensure that equipment can be physically produced as it is needed.

Finally, I believe that more development is necessary on methods the IAEA might use in simplifying resident inspection. Some examples are inexpensive and reliable intrusion monitors and simple methods of monitoring packages and vehicles to verify that they do not contain fissile material.

On that note, I would like to express my appreciation again for your invitation to attend and dicuss these subjects.

[The prepared statement of Dr. Kouts follows:]

Testimony By

Dr. Herbert Kouts

Before the Subcommittee on Energy Research and Production

Committee on Science and Technology

U.S. House of Representatives

August 4, 1982

Technical Aspects of Nuclear Non-Proliferation: Safeguards

It is a distinct pleasure to have this opportunity to discuss safeguards and non-proliferation programs before this subcommittee.

My name is Herbert Kouts. I am Chairman of the Department of Nuclear Energy at Brookhaven National Laboratory. My department consists of about three hundred persons, mostly scientists, engineers, and professionals who are specialists in aspects of nuclear energy. Most of the activities of our department are related to safety of nuclear power plants, including light water reactors, high temperature gas-cooled reactors, and fast breeder reactors. But we do conduct programs in other nuclear-power-related subjects also. Among these is the field of safeguards applied to fissionable material, to protect against unauthorized or undesirable uses, and safeguards against diversion of fissile material that could lead to proliferation of nuclear weaponry to additional nations of the world.

We have had a strong program in safeguards since 1968, when the old Atomic Energy Commission asked us to form a Technical Support Organization, which would serve as a close-coupled advisory body that could review the AEC's programs and recommend means of improving them. Though the organizational arrangement for safeguards in DOE is somewhat different from the one the AEC had structured in 1968, this relationship has been maintained. The Technical Support Organization (or TSO) still works closely with the Office of Safeguards and Security of the Department of Energy, to provide technical assistance that rests on a long history of detailed involvement by Brookhaven in the nuclear fuel cycle.

Because the Technical Support Organization is asked to advise DOE on technical requirements, it does not generally engage in DOE's programs of research on hardware. That is, it does not do research and development for DOE on methods of measurement of fissile material, on physical protection methods, or on surveillance devices. TSO becomes involved in using and applying the products developed by other laboratories but it does not often make new ones. There are some rare exceptions.

I should add that TSO is not only called on by the Department of Energy for assistance; it also responds to needs by other government agencies, such as the Nuclear Regulatory Commission, the Department of State, and the Arms Control and Disarmament Agency.

I should like to list briefly some representative tasks that TSO has undertaken during the last several years:

- In 1975, TSO assisted the new Nuclear Regulatory Commission (NRC) in performing the special studies required by the Energy Reorganization Act of 1974 and subsequently in developing more reliable domestic safeguards strategies for the back-end of the fuel cycle.
- President Carter initiated the Nonproliferation Alternative Systems Assessment Program (NASAP) and the International Nuclear Fuel Cycle Evaluation (INFCE). TSO personnel participated in studying the domestic and international safeguards implications of alternative nuclear fuel cycles, in drafting safeguards papers and in analyzing the safeguards proposals of other nations involved in the INFCE.
- In 1975 the IAEA requested assistance in preparing for the application of IAEA safeguards to selected U.S. facilities under the President's offer. The first exercise was a joint project of General Electric and TSO to provide design information to the IAEA on the G.E. Wilmington fuel fabrication facility, to develop means to transmit reports to the IAEA in a form compatible with the Agency's data system and to assist the IAEA in conducting an inspection. Subsequently,

TSO personnel have worked with the NRC, DOE and U.S. facilities in learning how to cooperate effectively with the IAEA now that the President's offer has been implemented.

- TSO has played an important role, together with Union Carbide/ Oak Ridge, Los Alamos and Sandia Laboratories in developing and evaluating alternative inspection strategies for uranium enrichment plants. Presently, TSO provides assistance to the U.S. delegation on the Hexapartite Enrichment Plant Safeguards group (U.S., U.K., Netherlands, W. Germany, Japan, Australia, Euratom and IAEA) which is attempting to develop international agreement on safeguards for such facilities. A related TSO assignment has been to study the features of the three alternative advanced enrichment techniques which would affect the application of international safeguards.
- For many years, TSO has assisted the AEC, ERDA and DOE in evaluating the safeguards at the government owned facilities and in designing and implementing more effective safeguards methods and techniques. Recently, TSO has been involved in studying the potential consequences of the theft of nuclear materials or sabotage of nuclear facilities, legal matters affecting the response of DOE security forces, human factors that may contribute to improved domestic safeguards, and assistance in updating the Environmental Statement on the Liquid Metal Fast Breeder Reactor fuel cycle and the Environmental Report on the Clinch River Breeder Reactor.

> As an example of another type of activity, TSO recently generated a computer-based catalogue of safeguards instrumentation for use by safeguards personnel here and abroad.

These are only a few of a great many tasks that TSO has undertaken. TSO is the only laboratory-maintained group that works in safeguards across the board, in all aspects of safeguards important to the government except those directly involving the Department of Defense. At present, the staff consists of twenty individuals. Backgrounds and skills are highly varied. There are physicists, chemists, engineers, a statistician, a lawyer, and even an archeologist. At times the staff has included such other diverse backgrounds as economics and sociology. The annual budget from all sources is now about 1.8 million dollars. TSO specializes when necessary in fast-response problem solving. This is often necessary.

Since 1976, Brookhaven has maintained another safeguards group, independent from the Technical Support Organization. This is the International Safeguards Project Office (or ISPO), which administers for the Department of State the U.S. Program of Technical Assistance (POTAS) in safeguards to the International Atomic Energy Agency. This program was initiated through a clause in the State Department's FY 1975 funding legislation, establishing a five-year program at a million dollars per year, to help IAEA in satisfying urgent needs that could not be met under the regular IAEA budget. In 1976, because of its long and deep involvement in many aspects of IAEA safeguards, Brookhaven was asked to form this new group to administer the program. The program has been such a success, and has been so important in helping IAEA to build capability for its difficult task, that the level of funding is now about four to five million dollars per year, and the duration has been extended. The total expenditures under the POTAS program are now about 27 million dollars. This U.S. technical assistance program has contributed significantly to IAEA safeguards. Similar programs have now been instituted by Canada, the United Kingdom, the Federal Republic of Germany, Japan, and Australia. These other programs now add up to a total magnitude approximately equal to that of POTAS.

ISPO formally receives its directives from the Office of Safeguards and Security of the Department of Energy. Oversight over the POTAS program is maintained by an interagency Technical Support Coordinating Committee which is chaired by the Department of State and which includes representatives of the Department of Energy, the Nuclear Regulatory Commission, and the Arms Control and Disarmament Agency. This committee meets monthly.

ISPO consists of a staff of seven people, of whom five are scientific and technical, with extensive experience in IAEA activities. Three of the five have been members of the IAEA staff. One of the five is always in residence in Vienna, where IAEA is situated, and in fact the Vienna resident of ISPO functions as a de facto member of the staff of the U.S. Mission to IAEA. The position of Vienna representative is rotated among ISPO staff on an annual basis.

Brookhaven maintains a bank account for POTAS in New York which is drawn on directly by IAEA in paying the approved out-of-pocket costs of the U.S. assistance program. These costs include, for example, the salaries and expenses of numerous technical experts who are supplied by the U.S. program, and who formally are members of the IAEA's safeguards staff.

The program consists of tasks that satisfy specific requests made formally by the IAEA. A request made by the IAEA is first discussed in detail with ISPO to determine if it is suitable for the U.S. program and how it can be satisfied, and to establish how urgently it is required. The formal request is reviewed by the Technical Support Coordinating Committee, which must approve it before it is included in the program. It is subsequently worked into a planned POTAS task. Some tasks, particularly recruitment of technical experts required by IAEA for special jobs, are done by ISPO itself. Most tasks involve some activity by a U.S. group expert in some specific area of safeguards. Most of these groups are in DOE laboratories, such as Los Alamos, Sandia, and Oak Ridge. ISPO negotiates with the appropriate laboratory for an agreement to undertake the task, arranging details of cost and schedule. The final tasking order to that laboratory is issued by the Office of Safeguards and Security of DOE.

ISPO then continues to monitor the work under the task until completion, including the conformance to schedules and costs. Problems, if they arise, are brought to the attention of DOE and the Technical Support Coordinating Committee.

Other features of the ISPO activities assure proper liaison with all the elements involved in the support operation. Formal meetings with IAEA are scheduled each six months to review progress, discuss forthcoming requirements, and settle problems. The ISPO staff member resident in Vienna holds discussions almost daily with IAEA staff and with his associates back at Brookhaven. Each DOE laboratory participating in the POTAS program has a program coordinator; program coordinators meet approximately twice a year at successive laboratory sites for a complete program review.

The POTAS program has so far included 309 tasks. Of these, 220 have been completed and 51 are now active. Thirty eight tasks originally included in the program have been deleted as being inappropriate, reassessed as having low importance, or for other reasons.

ISPO has also been used by the government for other aspects of international safeguards. ISPO managed the U.S. financial contribution to defray IAEA costs under the International Nuclear Fuel Cycle Evaluation program I referred to earlier. ISPO also managed the recent joint U.S.-Japanese program of experiments at the Tokai-Mura spent fuel reprocessing pilot plant. This program is formally called the "Tokai Advanced Safeguards Technology Exercise", or TASTEX. ISPO also assists in recruiting qualified U.S. nationals to fill vacancies in the IAEA's regular safeguards staff.

Tasks are undertaken to assist IAEA in several areas. Advanced instrumentation is made available, to be used in improving inspections. Systems studies are conducted, to improve IAEA safeguards methods. Tests of safeguards methods and equipment are conducted, with participation by IAEA inspectors. Cost-free experts are provided to the IAEA for one to two year periods, to ensure that IAEA can have on its staff the best technical expertise. Training courses are conducted for IAEA inspectors. Courses are given at Los Alamos in methods of non-destructive analysis of fissionable material. Instructors are provided cost-free for other courses given by the IAEA.

Some of the specific accomplishments of the POTAS program have been:

- More than forty items of equipment of eighteen different types have been given to the IAEA, for test, evaluation, and use in safeguards under the non-proliferation treaty. Some of these instruments were for measurement and assay of fissionable material, and some were for surveillance. The instruments were made to IAEA specifications, and their development and manufacture were usually followed by IAEA from the start.

Instruments were delivered with operation manuals and instructions, and scientists from the DOE laboratory doing or managing the development went to Vienna or the appropriate location to give instruction in use and to conduct tests in the field.

- About eighty man-years of cost-free expert assistance have been provided the IAEA, through highly skilled scientists and engineers who have served on the IAEA staff at U.S. expense. The cost to POTAS of this expert assistance has been about 6.5 million dollars so far. At present, seventeen cost-free experts from the U.S. are on the IAEA staff, funded under the POTAS program.
- All new IAEA inspectors are trained at Los Alamos in methods of non-destructive assay of fissile material that they will use in the field. The methods and instruments on which they are instructed have been developed in the U.S., and the instruments are of the kinds furnished the IAEA under the POTAS program.
- POTAS has funded instruction given by IAEA to safeguards personnel from other countries, in methods of safeguards to be used by their individual countries.
- Detailed systems analyses have been conducted on a number of problems important to the IAEA safeguards system. These have covered such topics as safeguards for certain types of facilities, methods of estimating cost-effectiveness relation-

ships, future IAEA needs, novel safeguards methods, and similar topics.

- The information system used by IAEA to keep track of fissile material in NPT signatory countries has been improved through review of the system in use and the provision of expert assistance in redesigning it.
- IAEA inspection personnel have become acquainted with methods and problems of safeguards at large fuel cycle facilities, through visits to and exercises conducted at large U.S. industrial plants. This experience was valuable in that the IAEA inspectors learned a great deal about problems they would encounter later in large facilities elsewhere in the world.
- Several kinds of seals and sealing systems for special or general use have been developed for IAEA, and prototype seals have been delivered for test and evaluation. IAEA sealing systems generally use the technology furnished under the POTAS program.

These are only a few of the many ways by which the POTAS program has helped to improve IAEA safeguards. We have been assured a number of times by the Director General of IAEA and by the Deputy Director General for Safeguards and Non-Proliferation that POTAS has contributed significantly to the effectiveness of the IAEA. We at Brookhaven are, of course, very pleased to have the ability and opportunity to help in such a meaningful way as managing this program for the United States Government.

This completes the description of the Brookhaven programs in support of safeguards. From what I have said, it is clear that these programs are closely coordinated with those at other laboratories, and with the activities of those agencies and departments of the executive branch that participate in the safeguards program of the government. Brookhaven safeguards personnel are in constant contact with the staff of the Office of Safeguards and Security of the Department of Energy, with personnel of the Division of Safeguards of the Office of Nuclear Material Safety and Safeguards of NRC, and the non-proliferation staff members of the Department of State and the Arms Control Agency. We are also in constant contact with the International Atomic Energy Agency and the U.S. Mission to the IAEA. We have begun a formal coordination of the U.S. assistance program with those of other countries.

I would now like to comment briefly on the adequacy of equipment used for non-destructive assay of fissile material, and for containment and surveillance, domestically and by the International Atomic Energy Agency.

My first comment is that the equipment best suited to the job is somewhat different in the two cases, since the missions of domestic and international safeguards are different.

In the domestic sphere, there are two safeguards systems: that used by DOE contractors in connection with special nuclear material possessed by DOE, and that used by private concerns for special nuclear material they own and possess under license from the Nuclear Regulatory Commission. In the former, the DOE contractors apply safeguards in conformance with DOE Orders. They report transfers and holdings to the DOE information system. DOE verifies inventories, ensures compliance with physical protection requirements, and investigates abnormal events. The latter system for privately owned material is quite similar in structure in that there is an information system to assimilate and analyze reported transfers of special nuclear material, and there are scheduled inspections to verify reported information and to check on conformance with NRC requirements. The systems have numerous differences of detail resulting from the non-identical requirements. But the similarities are evident: strong methods of physical protection are required, and the numerical data from reports and from inventories are used to develop secondary confirmation that in fact the protection methods have worked effectively.

The IAEA's methods generally lack the physical protection aspect, because international bodies such as IAEA do not have the sovereignty necessary to conduct or control police methods. IAEA is restricted by governing agreements to verification of accounting data. I know of only two departures from strict interpretation of this limitation. The first is requirement by the IAEA that physical protection be included in the State's system of safeguards; an excellent IAEA guide has been issued defining typical features of the physical protection system a State should maintain. Second, there has been support which is substantial but not universal for IAEA ability to ensure through continuous presence or resident inspection that accounting data are complete in such vital areas as isotope separation or chemical reprocessing.

There is a strong confluence of domestic and international requirements only in regard to methods of measurement of amount and composition of fissile material. The measurement methods requiring most attention have been the nondestructive ones, since ordinary chemical analysis is pretty good already, even if it is not perfect.

In non-destructive methodology we are limited by several considerations. Nature limits the possibilities of methods. Practical considerations limit the methods that can reasonably be used. For instance, the IAEA particularly needs instruments that are easily transportable into hostile climates, and that can be used reliably even where such technological problems exist as abnormal line voltages and uncertain repair capabilities.

I believe that the DOE development program and the POTAS program are providing the domestic and the international safeguards systems with non-destructive assay equipment which is about as good as the current limits of technology permits. As technology improves, it is quickly taken advantage of by the program.

The same is true of surveillance equipment being furnished the IAEA under the POTAS program, particularly automated television recording equipment. The program uses the most advanced technology available that can be made to function reliably under the difficult conditions IAEA encounters.

I believe there are still some definite technical requirements for IAEA safeguards, that must be filled if the IAEA's non-proliferation objectives are to be met.

First, equipment of the kind the POTAS program has been supplying must reach the state of common use by the IAEA inspection staff. So far, the movement from test to evaluation to application has been too slow. The problem is recognized and has been discussed with IAEA. Improvement of implementation is the present prime objective of the POTAS program. Solution of this problem is difficult, but with the cooperation of the Agency I am sure we will succeed.

Second, the long-term plan for procurement of equipment by IAEA must be carried through. Dr. William Higinbotham of the Technical Support Organization has identified a requirement for about twenty million dollars of equipment over the next five years. This requirement has now been incorporated into the IAEA's operating budget projections. But only prototypes exist for many of the items needed, and commercial sources do not exist for many other kinds. A determined effort is needed to ensure that equipment can be physically produced as it is needed.

And finally, I believe that more development is necessary on methods the IAEA might use in simplifying resident inspection. Some examples are: inexpensive and reliable intrusion monitors, and simple methods of monitoring packages and vehicles to verify that they do not contain fissile material.

I wish again to express my appreciation for the invitation to present this information and these views to your subcommittee.

Mrs. BOUQUARD. Thank you very much, Dr. Kouts, for your excellent testimony.

Dr. Myre, we look forward to your presentation. Please proceed.

STATEMENT OF DR. WILLIAM C. MYRE, DIRECTOR, NUCLEAR SECURITY SYSTEMS, SANDIA NATIONAL LABORATORIES

Dr. Myre. Thank you, Madam Chairman.

Madam Chairman and members of the committee, it is a pleasure for me to be here to discuss the technical aspects of nuclear nonproliferation safeguards. In this testimony I plan to summarize my formal statement which has been provided for the record.

Mrs. BOUQUARD. We have your written testimony. You may proceed as you wish, Dr. Myre, and your entire testimony will be made a part of the record.

Dr. MYRE. Thank you.

I agree with your committee that safeguards are essential to validate that nuclear energy is used for peaceful purposes. I further believe that advanced technology has a major role to play in providing effective and efficient safeguards.

Sandia National Laboratories, as a major R&D laboratory in the Department of Energy's nuclear weapons development complex, has for a number of years had a significant R&D program supporting the safeguarding of nuclear weapons and materials. It has always been a major objective of the U.S. nuclear weapons program to produce nuclear weapons that provide, as an inherent feature of their design, maximum resistance to malevolent tampering. It was this program that provided the technology base that allowed us to be able to support the increased national emphasis on both domestic and international safeguards beginning in the late 1960's and early 1970's.

Our first major program in domestic safeguards was to design and build the DOE's system to transport safely and with adequate security those nuclear materials and weapons that are in the Department's possession. More recently we have developed a technology base in physical protection systems and components which has been used to support the upgrading of security systems at various DOE, DOD, and NRC-licensed facilities which have nuclear materials. Also, through bilateral exchanges and an annual Department of State and IAEA-supported international training course on physical protection, we have transferred this technology to foreign nations with existing or planned nuclear power programs.

This same technology base has also provided us the necessary capability to design advanced containment and surveillance equipment for use by the IAEA. My written testimony emphasizes our work on containment and surveillance equipment.

The Non-Proliferation Treaty in its preamble emphasizes support for the development of technical measures for more effective safeguards. These fall generally into the areas of material measurement and containment and surveillance. Containment and surveillance measures provide information on movements of nuclear material or on the integrity of items through the use of seals, optical surveillance devices, and monitors. This equipment assists in providing a continuity of knowledge of nuclear material location and flow between routine IAEA inspections. The unattended use of this equipment places prime importance on reliable performance and tamper resistance.

Sandia's containment and surveillance activities commenced in the late 1960's, principally under the sponsorship of the Arms Control and Disarmament Agency. When the U.S. Program of Technical Assistance to IAEA safeguards was initiated in the mid-1970's, Sandia became one of the principal U.S. laboratories for the POTAS containment and surveillance tasks. Since the beginning of POTAS we have been responsible for 40 tasks in the broad areas of seals, optical surveillance devices, monitors, training, and the provision of cost-free experts.

The increased attention given to international safeguards in the mid-1970's, coupled with the U.S. policy decision to defer reprocessing and the potential impact of placing selected DOE facilities under IAEA safeguards, led to the establishment of the DOE initiative program. Within the framework of this program, Sandia's task objectives are to, one, develop international safeguard designs and strategies for DOE facilities potentially subject to international inspection, for example, the Gaseous Centrifuge Enrichment Plant, and foreign facilities of high national interest such as reprocessing and on-line-refueled reactors; two, support implementation of effective international safeguards through development, test, and demonstration of containment and surveillance technology and containers for air transport of nuclear material samples; three, exchange technical information on containment and surveillance concepts and equipment pursuant to agreements with various foreign governments and organizations; and four, provide training of personnel from foreign countries and exchange of technical information to encourage implementation of appropriate physical protection of nuclear facilities.

My written statement provides more detail on these programs and how they relate to IAEA's safeguards activities.

Sandia developments have resulted in new containment and surveillance devices and techniques now in use by the Agency as well as several items currently under evaluation prior to a decision by the IAEA on operational implementation. As the IAEA safeguards inspection activities continue to expand, new requirements will arise and operational constraints will become more exacting. Facilities under safeguards will grow in numbers and diversity.

As the inspector workload grows, there will be an increasing need for instruments that are simpler to operate and maintain and for unattended, tamper-resistant equipment. The rapidly advancing state of the art in microprocessors and video devices will provide new opportunities for application to IAEA safeguards operations. Finally, as safeguards system concepts continue to evolve, equipment will need to be developed to implement them.

Several of these factors that will assume increasing importance can be generalized under the heading of implementation. Such things as procurement specifications, maintenance planning, parts lists, instruction manuals, periodic training, and parts resupply must be developed and provided in ways that are compatible with the Agency's infrastructure and resources. Implementation has received increasing attention in recent years and progress has been made but much more remains to be done, and as the Agency's operations continue to grow, the problems of implementation over an equipment's lifetime will demand an increasing proportion of the technical development effort.

As this subcommittee has demonstrated in calling these hearings, measures to control the proliferation of nuclear weapons have a large technical component. The technical aspects are complex, covering many intricate details of nuclear operations, specialized measurements, surveillance technology, and operations analysis. Other aspects of the problem are institutional and in the field of foreign relations. The problem is especially complex because of the interaction among these diverse fields of specialized knowledge.

Sandia's role is to provide a center of technological development in the broad field of physical protection and containment and surveillance, to integrate those efforts with those of other groups—both national and worldwide—and to make our resources and specialized knowledge widely available.

Madam Chairman and members of the subcommittee, I would be pleased to answer any questions you may have.

Thank you.

[The prepared statement of Dr. Myre follows:]

Testimony Presented by

WILLIAM C. MYRE
DIRECTOR OF NUCLEAR SECURITY SYSTEMS
SANDIA NATIONAL LABORATORIES
ALBUQUERQUE, NEW MEXICO

To

The Subcommittee on Energy Research and Production
of the
Committee on Science and Technology
U.S. House of Representatives

On

TECHNICAL ASPECTS OF NUCLEAR NON-PROLIFERATION: SAFEGUARDS

August 4, 1982

INTRODUCTION

Madam Chairman and Members of the Committee, it is a pleasure for me to be here to discuss the "Technical Aspects of Nuclear Non-Proliferation: Safeguards." Sandia National Laboratories as a major Research and Development laboratory in the Department of Energy's nuclear weapons development complex has, for a number of years, had a significant R&D program supporting the protection of nuclear weapons and materials. It is my objective in this testimony to briefly describe that program and how our activities support national security and non-proliferation objectives. I will focus on our technical programs in the area of international safeguards.

It has always been a major objective of the United States' nuclear weapons program to produce nuclear weapons which provide, as an inherent feature of their design, maximum resistance to malevolent tampering. It was this program that provided the technology base that allowed us to be able to support the increased national emphasis on both domestic and international safeguards beginning in the late 1960's and early 1970's.

Because of the potentially catastrophic consequences of nuclear materials being used for malevolent purposes, the DOE has supported a continuing program to develop physical protection technology and systems for protecting nuclear materials. This program addresses all the elements of a complete physical protection system: detection, delay, communication, and response. Our first major program in physical protection was to design and build the DOE's system to transport safely and with adequate security those nuclear materials and weapons that are in the Department's possession. In the last decade we have developed a technology base in physical protection systems and components which has been used to support the upgrading of security systems at the various DOE facilities which have nuclear materials.

The goals of our physical protection R&D program are to (1) increase understanding and definition of security-related problems, (2) expand, as required, breadth and depth of the technology base, (3) support security upgrades at existing DOE facilities, and (4) spin-off the technology to other organizations with similar problems. The program includes the related activities of system analysis and conceptual design; technology development, test, and evaluation; and system design, development, and implementation at specific sites. Important functions are to enhance technical exchanges among government agencies, facility operators, and responsible organizations and to transfer technology through handbooks, performance specifications for equipment, seminars, workshops, and participation in professional conferences.

Sandia has also been involved with safeguards programs for the NRC since 1975. The initial work included participation in a comprehensive study to summarize current safeguards technology, nuclear facility protection, and in-transit protection systems. Since that time, major work for the NRC has included the development of methods for evaluating physical protection systems at nuclear facilities and in-transit systems. This work has progressed through a methodology development phase, a demonstration phase, and a technology transfer phase. Today, many of these techniques have been utilized by NRC, DOE, and DOD personnel for evaluation and design purposes. Current methodology includes computerized analysis programs such as the Safeguards Automated Facility Evaluation (SAFE), the Safeguards Network Analysis Procedure (SNAP), and the Estimate of Adversary Sequence Interruption (EASI) techniques.

In addition to the physical protection programs for the DOE and the NRC, we have utilized this same expertise to support high level security system programs for a number of other US Government agencies, primarily the DOD. Sandia supports the military services in designing and deploying hardware and software for detection and assessment capabilities at nuclear storage sites. We are also providing hardware for demonstration of various delay elements for potential deployment at DOD weapon sites.

Although the end application is different, elements of the technology base generated as a result of the physical protection programs described above are directly applicable to international safeguards system requirements. Specific areas include tamper protection, detector development, microprocessor-based data collection and display, closed-circuit television surveillance, and systems analysis techniques.

International Safeguards

The system of safeguards to prevent the proliferation of nuclear weapons is based on the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), which became effective in 1968. The Treaty provides for peaceful uses of nuclear energy, and relies upon safeguards administered by the IAEA to provide assurance that peaceful activities are not used in any way for military weapons or explosives. The IAEA system of safeguards is built upon State systems of nuclear-material accounting and control, relying on physical protection provided by the State under its sovereign police powers. The IAEA provides guidelines for those State systems to assist in promoting higher standards of coverage and performance.

The assurance provided by IAEA safeguards is based on accounting for all nuclear materials within the territory of the State that are subject to safeguards, since nuclear material in some form is essential for weapon production. Operational activities center on in-country inspection of nuclear facilities and materials, in order to verify by independent measurement and observation the periodic reports submitted by States under specific agreements. The Agency's inspections consist of audits of the State's records and reports for internal consistency and correlation with other States' reports at shipper/receiver interfaces; separate and independent measurements and analyses of randomly-selected, tamper-resistant surveillance devices; widespread use of seals to provide continuity of coverage; and periodic physical inventories of nuclear-material stocks.

The NPT, in its preamble, emphasizes support for the development of technical measures for more effective safeguards. These fall generally into the areas of Material Measurement and Containment and Surveillance (C/S). C/S measures provide information on movements of nuclear material and the integrity of items, through the use of seals, optical surveillance devices, and monitors. This equipment assists in providing a continuity of knowledge of nuclear material location and flow between routine IAEA inspections. The unattended use of this equipment places prime importance on reliable performance and tamper resistance.

INTERNATIONAL PROGRAM DESCRIPTION

IAEA Direct Support

ACDA Sponsored Program--Sandia's C/S activities commenced in the late 1960's, principally under the sponsorship of ACDA. The initiation of our involvement in this work was a direct outgrowth of the extensive technological expertise acquired from the weapon and satellite development activities of the Laboratories. The C/S activities included the design, development, and evaluation of:

1. Bundle counters for use in on-line-fueled CANDU reactors. These counters detect and record the transfer of spent fuel bundles from the reactor to the fuel storage pool.

2. A photographic surveillance camera with a time/date display, motion detector and radiation detector. These cameras, activated by the motion and/or radiation detectors, provide for continuous surveillance of CANDU fuel storage pools.

3. An unattended doorway nuclear material monitor with data storage, tamper protection, and optical surveillance features. The routine passage of all personnel through the doorway is monitored; detection of nuclear material during these passages is recorded for subsequent review.

4. A leached hull monitor, a crane monitor, a shipping dock monitor and a reactor power monitor. While development of these monitors was not completed, the techniques have been applied in subsequent developments.

The bundle counter and the surveillance camera were developed and evaluated within the framework of a joint US/Canadian program. One of the bundle counters was installed in the Canadian Pickering Power Station and is still in use by the IAEA. Both the bundle counter and the camera designs have been adapted by Canada for use in CANDU 600MW safeguards systems to be applied in Canada, South Korea, and Argentina. A photographic surveillance camera was also provided to the FRG for independent evaluation. The doorway monitor was jointly evaluated as part of a cooperative effort between the US and the UK.

From 1969 to 1978, a total of $1.1M was spent by Sandia on these activities.

POTAS Program--As a result of increased emphasis on domestic and international safeguards, the US Program for Technical Assistance to IAEA Safeguards (POTAS) was initiated in the mid-1970's. The objective of this program is to provide support for the near term, urgent needs of the IAEA in the areas of measurement technology, training, system studies, information processing and evaluation, and containment and surveillance. As a result of the earlier C/S work, Sandia became one of the principal US laboratories for the POTAS C/S tasks. Since the beginning of POTAS, we have been responsible for 40 tasks in the broad areas of seals, optical surveillance devices, monitors, training, and provision of cost-free experts. Principal Sandia POTAS activities include:

1. Improvements in the tamper resistance and corrosion resistance features of metallic seals, resulting in the Double Cap Type "E" seal and the Type "X" seal. Double Cap Type "E" seals are in routine use by the IAEA, and the Type "X" Seal is being used in some special applications requiring increased protection against corrosion.

2. A semiautomatic film scanner which aids inspectors in reviewing Super-8mm surveillance film. Significant changes detected in a film frame are stored on a video disc recorder for subsequent review by the inspector. This scanner is in routine use at the Agency's Headquarters and has increased the review efficiency by reducing the time required for detailed review of the film.

3. A surveillance television and recording system to replace the existing IAEA CCTV System. This microprocessor-controlled system uses two cameras and redundant video tape recorders, and has been designed with reliability as a principal goal. Additional features include motion detection, tamper protection, tamper event annotation, battery back-up, and semiautomatic playback analysis. In addition, an optional additional recorder is available for use in joint IAEA/Euratom inspections. Six of these systems are in the latter stages of evaluation with routine use by the Agency expected in early 1983.

4. A prototype portable CCTV system to provide unattended surveillance in inspection situations where the inspector cannot be present during the entire operation of interest, such as reactor refueling. Evaluation of this system by the Agency has been completed, resulting in demonstration of the feasibility of this concept. Provision of field evaluation versions of this system, using advanced CCTV technology, is expected in late 1983.

5. An integrated monitoring system consisting of sensor, data collection, and data display equipment. This equipment was developed as a supplementary measure to optical surveillance. The data collection and display equipment can be adapted to interpret, store, and display the data from a wide variety of sensors. The display equipment is portable and provides the inspector with a permanent record of all sensor-detected events.

6. A study of the feasibility of applying an integrated C/S system in the fuel receiving and storage areas of the Japanese Tokai-Mura Reprocessing Plant. This was part of the Tokai Advanced Safeguards Technology EXercise (TASTEX) to investigate the improvement of safeguards at reprocessing plants. A conceptual design was generated for a system which monitored all significant fuel transfers into and out of storage. In support of this design, data was collected at the facility during fuel transfer operations to validate the proposed design of selected instruments.

7. Provision of cost-free experts to serve on the Agency staff to assist in the areas of:

   a. Management of C/S development and implementation activities.
   b. CCTV reliability analysis
   c. C/S equipment test and evaluation
   d. Formulation and conduct of inspector training courses

Other POTAS activities have included evaluations of film cameras and video tape recorders; studies related to before-the-lens tampering, seal verification techniques, tamper indicating containers, status monitoring, film developer kits, and improved equipment reliability; and development of laboratory prototype electronic seals and slow-scan CCTV systems.

From FY1977 through FY1981 total Sandia expenditures on this program have been $4.1M. Our FY1982 expenditures are expected to be $0.54M.

DOE Initiative Program

The increased attention given to international safeguards in the mid-1970's, coupled with the US policy decision to defer reprocessing and the potential impact of placing selected DOE facilities under IAEA safeguards, led to the establishment of the DOE Initiative Program. Within the framework of this program, Sandia's task objectives are to:

1. Develop international safeguards designs and strategies for DOE facilities potentially subject to international inspection; for example, the Gaseous Centrifuge Enrichment Plant; and foreign facilities of high national interest, such as reprocessing and on-line-refueled reactors.
2. Support implementation of effective international safeguards through development, test, and demonstration of (a) C/S technology and (b) containers for air transport of nuclear material samples.
3. Exchange technical information on C/S concepts and equipment pursuant to agreements with various foreign governments and organizations.
4. Provide training of personnel from foreign countries and exchange of technical information to encourage implementation of appropriate physical protection of nuclear facilities.

The FY1982 funding for all of these activities is $2.9M.

Conceptual Designs--C/S safeguards system designs and strategies have been evaluated for most major nuclear facility types. Extensive analysis efforts have been applied to reprocessing and enrichment plants. Less extensive studies have been conducted for facilities such as fast breeder reactors, fast critical assemblies and away-from-reactor storage facilities.

The reprocessing plant analysis activities resulted in the publication of a joint Sandia/Los Alamos report entitled "Integrated International Safeguards Concepts for Fuel Reprocessing." In this study a safeguards strategy was developed which integrated nuclear material accounting and C/S concepts into a combined system design that considered both abrupt and protracted diversion. Analytical methods were developed for the evaluation of the effectiveness of selected elements of the conceptual system.

The C/S work that was accomplished by Sandia as part of this reprocessing plant study contributed to the selection of the United States to be the convenor of the C/S subgroup of the International Working Group on Reprocessing Plant Safeguards. This Subgroup was comprised of participants from the IAEA, UK, France, FRG, Belgium, India, Japan, and Euratom, with Sandia being the lead US laboratory. The subgroup reviewed the proposed techniques for quantification of the assurance from C/S, updated information on C/S devices, and developed a unified approach to the design and evaluation of C/S systems for penetration monitoring. This unified approach incorporated elements of evaluation concepts that had been independently developed by the participants.

The objective of the enrichment plant analysis efforts has been to define an efficient and effective system for safeguarding enrichment plants. In the early 1970's, efforts were directed toward the Almelo plant located in The Netherlands and then later to the Gaseous Centrifuge Enrichment Plant (GCEP) at Portsmouth, Ohio.

GCEP studies, conducted by Sandia in conjunction with participants from Union Carbide-Oak Ridge, Los Alamos National Laboratory and Brookhaven National Laboratory, have resulted in conceptual C/S systems for inspection strategies that allow inspectors to have access to the cascade area as well as strategies that prohibit inspector access to these sensitive areas. Tradeoffs between system effectiveness and the exposure of sensitive technology to foreign nationals are an integral part of these studies and the hardware development that resulted from the analysis.

The experience gained during the GCEP and Almelo analysis and hardware development efforts has been applied to the ongoing Hexapartite Safeguards Project. Sandia's contributions to this project, conducted in conjunction with participants from the UK, FRG, The Netherlands, Australia, Japan, Euratom, and the IAEA, have included an identification of C/S instruments which could be used in enrichment plants. In addition, a number of documents on product enrichment monitors, perimeter systems, tamper protection and personnel portals were provided.

C/S Equipment Development--The hardware activities related to the DOE Initiative Program have included work in all areas of C/S: seals, optical surveillance, and monitors.

In the area of seals, the principal activities are related to in situ verification and improved tamper resistance. In situ verification eliminates the time lag presently incurred by the necessity of returning the seals to Headquarters for identity and integrity verification. In addition, it allows additional on-site investigative activities in cases of questionable seal identification or integrity. The major seal activities are discussed below.

1. An in situ verifiable fiber optic general purpose seal system has been developed and field evaluation models have been delivered to the Agency. This system consists of a mechanism which seals the ends of a fiber optic loop, and a portable verification unit used to determine the identification and integrity of the sealing mechanism and the fiber optic loop.

2. An in situ verifiable UF_6 cylinder valve seal has been developed and delivered to the Agency for evaluation. This seal is made by placing shrink tubing with imprinted identification marks over the valve. Heat shrinking provides a unique identification pattern in the tubing, which cannot be removed without destruction of the pattern. This seal prevents undetected removal of UF_6 through the valve.

3. Prototype development of a Fuel Assembly Identification Device (FAID) for BWR assemblies has been completed and a field evaluation at the Kahl Reactor in the FRG is scheduled to commence in late 1982. Design of this device was based, in part, on the early ultrasonic seal technology developed by the Commission of European Communities, Joint Research Center (CEC/JRC), Ispra, Italy. The FAID is secured to the top of the fuel assembly in a manner which precludes removal without destruction of the unique identification characteristics. In concept, the FAID would be attached on fresh fuel at the fuel fabrication facility at the time the nuclear material content is determined. It would remain on the fuel assembly throughout its lifetime.

4. A common ultrasonic seal reader is being developed for reading the FAID described in (3) above, the Canadian developed cap seal for CANDU fuel bundle cages, and other ultrasonic seals developed by CEC/JRC, Ispra. Through the use of the reading equipment, the identification and integrity of the seals are read and compared with pre-read and stored data. A permanent record of the results of the comparison data is provided for the inspector.

In the area of optical surveillance the principal objective is to investigate the potential C/S application of the rapidly advancing CCTV technology. A prototype small CCTV system has been developed using the latest commercial cameras and compact video tape recorders. This system will be demonstrated to the Agency in late 1982. This effort may ultimately lead to replacement of existing IAEA film camera systems with CCTV systems.

In the area of monitors, the principal objective has been to develop and evaluate new techniques which would complement seals and optical surveillance. This activity includes development of:

1. In-line product monitors for use in enrichment plants. These devices utilize a Los Alamos-developed detector which continuously monitors the enrichment of the uranium hexafluoride in the output product line. The monitor provides the inspectorate with a timely indication if the product exceeds previously defined enrichment levels. It can also be used with weight measurement data to support material accountancy measures.

2. A robot inspector for improving inspector efficiency. The initial application of this equipment is intended for enrichment plants. It collects enrichment data without requiring an inspector to be present at all times. The unit, containing radiation detectors, CCTV and a location monitor, can be moved to centrifuge locations by either inspectorate or facility personnel. Tamper resistance features allow high confidence in the validity of the data collected.

3. A high throughput, unattended personnel portal monitor. The high throughput capability is needed for facilities where large numbers of people enter material balance areas. This is achieved by using a commercially available revolving door. The detectors and data storage unit are contained in a tamper protected enclosure.

4. A passive environmental monitor which provides a simple, low cost means of determining the temperature, humidity and radiation extremes to which unattended C/S equipment has been exposed between Agency inspection intervals. This data will assist in (1) ongoing evaluation of C/S equipment performance, (2) determination of the causes of equipment malfunctions, and (3) evaluation of potential tampering activities involving exposure of the equipment to extreme environments. A prototype of this device will be demonstrated to the Agency in late 1982.

Containers for Air Transport of Nuclear Material Samples--Safeguards plutonium samples obtained in the field are transported to an IAEA safeguards analytical laboratory for quantitative analysis. Air transport is often necessary if the samples are to be analyzed in a timely fashion. Special crash-resistant packaging is necessary in order to meet the safety regulations of various countries for the air transport of plutonium. Sandia developed such a package, designated Plutonium Air Transportable Model 2 Package (PAT-2), which is licensed by the NRC and DOT to transport up to 15 grams of plutonium or uranium in various forms.

The PAT-2 weighs approximately 72 pounds, with a height of 14 inches and a diameter of 15 inches (less handles). It has been extensively tested to demonstrate its survivability under a variety of extremely severe environments related to aircraft crash conditions. It meets the requirements of 10CFR 71, 49 CFR 173, NUREG-0360, IAEA Safety, Series No. 6, and IATA (International Air Transport Association) rules.

Foreign Technology Exchange--In the area of foreign technical exchange, Sandia has participated in formal and informal exchange activities, as well as a variety of IAEA and European Safeguards Research and Development Association (ESARDA) activities. These exchanges assist in (1) avoiding duplication of R&D efforts, (2) providing for independent evaluations of C/S equipment, and (3) use of foreign facilities, to the extent practical, for field evaluation of C/S equipment. Specific activities include:

1. Formal bilateral exchange agreements with the FRG and the CEC. These agreements involve exchange of C/S and physical protection techniques and equipment in order to assist in furtherance of common objectives.
    a. The principal activities with the FRG relate to (i) joint evaluation of electronic seals developed by both nations, (ii) US evaluation and modification of an FRG rotary portal designed for domestic safeguards, (iii) exchange of information on intrusion sensors and reprocessing plant safeguards techniques and equipment, and (iv) test and evaluation of the FAID system applied to BWR fuel assemblies at the Kahl Reactor for long term in-reactor tests.
    b. With the CEC, the principal activity is related to collaboration with the Joint Research Center at Ispra, Italy, on ultrasonic seal technology. Emphasis has been concentrated on adaptation of our ultrasonic reader technology to ultrasonic seals developed by CEC/JRC.
2. Informal technology exchanges in the areas of physical protection and international safeguards have been in progress for approximately 10 years. These exchanges have been conducted with government and industry representatives at Sandia, as well as a variety of foreign locations. Through these exchanges, numerous contacts have been

established with personnel from approximately 30 nations, including Canada, UK, France, Belgium, FRG, Italy, Japan, and Australia.

3. Sandia participates in the ESARDA C/S Working Group meetings, which are held approximately two times a year, as well as annual ESARDA safeguards and nuclear material management symposia.

4. In addition to the many routine interactions with the IAEA on POTAS and DOE sponsored projects, Sandia participates in the Agency sponsored C/S Advisory Group meetings held once every two years and other C/S consultant group meetings and safeguards symposia.

International Training Course--The International Training Course (ITC) on the Physical Protection of Nuclear Facilities and Materials resulted from the convergence of three separate institutional processes and interests: (1) the presentation by Sandia under DOE/OSS sponsorship of a series of physical protection workshops for DOE field office and contractor personnel in 1977 and early-1978; (2) the mandate of the Nuclear Non-Proliferation Act of March 1978 that the DOE, in consultation with the NRC, offer training in safeguards and physical security for nuclear facilities to the international community; and (3) the interest of the IAEA in serving as a catalyst or clearinghouse for the dissemination of technological approaches that could help its member states meet guidelines for physical protection.

An agreement was negotiated with the IAEA by the US Mission to the IAEA on the behalf of the DOE. This agreement provided that training courses would be organized and presented by the DOE under the auspices of the IAEA. A committee of representatives from Sandia, DOE, NRC, and ACDA was established to review plans and materials for the first course, which was scheduled for November 1978.

The technical portion of the course was intended to introduce the attendees to the application of technology to physical protection of nuclear facilities and to present a systematic approach to design and evaluation of such physical protection systems. The design/evaluation technique was based on the principle that physical protection only succeeds if the functions of detection, delay, communication, and response are carried out in a coordinated fashion before an adversary succeeds in acts of theft or sabotage.

Guest speakers from the UK, France, Canada, and Iran were invited to lecture on the approach to physical protection in their national programs. The presentations in this first course were slanted to the attendees from developing countries in the early stages of peaceful nuclear power programs. As a result, there was extra emphasis on regulation and organization of nuclear programs.

The First ITC was held from November 1 to 15, 1978 in Albuquerque, NM. It was attended by 26 persons from 22 countries, selected by the IAEA from among 42 applications. The ITC has now been presented three additional times (see Table 1). For each successive course offering, the US/IAEA agreement has been renewed with only minor changes. The length of the course is now three weeks, including a field trip to a power reactor and to the Barnwell Nuclear Fuel Plant

Throughout the history of the ITC, sensitive topics such as the tactical application of security forces, and topics peculiar to a given country, such as legal constraints on use of deadly force, etc., have been scrupulously avoided. All course sessions are conducted in meeting rooms of local hotels far from any sensitive areas. The course continues to represent no more than an introduction to physical protection technology and its applications, but within that limited objective, follow-up discussions with past course attendees indicates an encouraging measure of success.

Table 1.
Training Course Presentations

#	Locaticn	Dates
I	Albuquerque	Nov. 1-15, 1978
II	Albuquerque/Barnwell	Nov. 28-Dec. 21, 1979
III	Albuquerque/Barnwell	Jan. 27-Feb. 18, 1981
IV	Albuquerque/Barnwell	May 4-26, 1982
V	Albuquerque/Barnwell	Sept. 7-29, 1983 (planned)

Table 2.
List of Countries Participating in ITC's

	Attendees	Speakers		Attendees	Speakers
Argentina	1	-	Italy	2	-
Australia	3	1	Japan	5	2
Brazil	4	1	South Korea	3	-
Bulgaria	1	-	Malaysia	2	-
Canada	5	2	Mexico	4	-
Chile	3	-	The Netherlands	1	-
Czechoslovakia	3	-	Pakistan	6	-
Denmark	1	-	Philippines	7	-
Egypt	3	-	Poland	2	-
Federal Republic of Germany	2	1	Portugal	1	-
			Romania	2	-
Finland	1	-	South Africa	4	-
France	3	3	Spain	4	-
Hungary	1	-	Thailand	2	-
India	5	1	Tunisia	1	-
Indonesia	3	-	Turkey	3	-
Iran	1	1	United Kingdom	-	1
Iraq	1	-	Venezuela	2	-
Israel	2	-	Yugolavia	2	-

DIRECTION OF FUTURE R&D

Sandia developments have resulted in new C/S devices and techniques now in use by the Agency as well as several items currently under evaluation prior to a decision by the IAEA on operational implementation. As the IAEA safeguards inspection activities continue to expand, new requirements arise and the operational constraints become more exacting. Some of the factors that generate a continuing need for future technological development and support are:

1. The rapidly-growing number of facilities that must be inspected, as new reactors become operational. The heavy demand on the Agency's resources will lead to a growing emphasis on more cost-effective technical measures.

2. New types of bulk-handling facilities, especially those involving plutonium, will come into more general operation over the next decade. Much work has been done in anticipation of that by the safeguards R&D community over the past few years. Much remains to be done, particularly when inspection needs for such facilities must be met in the face of heavy demands on inspector and financial resources.

3. New safeguards concepts and inspection strategies continue to evolve, with the efforts to make safeguards more efficient and effective. New concepts go hand-in-hand with, and at the same time are constrained by, progress in the equipment state of the art.

4. The continuing growth of IAEA safeguards operations will require increasing numbers of inspectors with suitable technical qualifications. As the technical equipment that the inspectors must operate grows in numbers and diversity, there will be growing emphasis on simplicity of operation, maintainability, reliability, and logistic support.

5. Much of the thrust of safeguards technological development is toward unattended, continuously-operating equipment, to provide continuity of coverage and to conserve inspector effort. Such equipment, if its output is to be credible, must provide assurance against tampering and falsification. The development of means for tamper resistance continues to be of growing importance.

6. The rapid advance of the state of the art, particularly in microprocessors and video devices, continually opens new possibilities for technical solutions to the Agency's

problems. A continuing R&D program over the longer term allows new developments in technology to be translated expeditiously into operating equipment tailored to the Agency's specialized requirements.

Several of these factors that will assume increasing importance can be generalized under the heading of implementation. The equipment development cycle continues through the production of prototype units for operational evaluation to the creation of a system to support lifetime operation. Such things as procurement specifications, maintenance planning, parts lists, instruction manuals, periodic training, and parts resupply must be developed and provided in ways that are compatible with the Agency's infrastruucture and resources. Implementation has received increasing attention in recent years, and progress has been made. At the June 1982 meeting of the IAEA C/S Advisory Group, in which Sandia participated, the Agency requested recommendations for improved acceptance testing. The Group recommended adoption of a specific implementation plan, based in part on work done by the US under POTAS. Much more remains to be done, and as the Agency's operations continue to grow, the problems of implementation over an equipment's lifetime will demand an increasing proportion of the technical development effort.

SUMMARY

As this Subcommittee has demonstrated in calling these hearings, measures to control the proliferation of nuclear weapons have a large technical component. The technical aspects are complex, covering many intricate details of nuclear operations, specialized measurements, surveillance technology and operations analysis. Other aspects of the problem are institutional and in the field of foreign relations. The problem is especially complex because of the interactions among these diverse fields of specialized knowledge.

Sandia's role is to provide a center of technological development in the broad field of physical protection and containment and surveillance, to integrate those efforts with those of other groups, both national and worldwide, and to make our resources and specialized knowledge widely available. The program is actively involved in in-house development, coordination and exchanges with similar programs elsewhere, and the transfer of technology to a wide variety of users.

This concludes my prepared statement. I hope that this testimony will help the Subcommittee gain further understanding of our R&D program and how it assists the IAEA by enabling them to more effectively perform their safeguards function.

Mrs. BOUQUARD. Thank you very much, Dr. Myre.

Dr. Shipley, will you proceed with your testimony?

[A biographical sketch of Dr. Shipley follows:]

Dr. James P. Shipley
Assistant Division Leader/Program Manager
Safeguards and Security
Los Alamos National Laboratory

James P. Shipley received the Ph.D. degree in 1973 from the Department of Electrical Engineering and Computer Science at the University of New Mexico. He also holds a Bachelor of Science in Electrical Engineering from New Mexico State University (1966) and a Master of Science in Electrical Engineering and Computer Science from the University of New Mexico (1969). Shipley's background is in electronics, automatic control systems, filtering theory, and applied mathematics for systems analysis. He has served as Group Leader of the Safeguards Systems Group, which is engaged in the development of advanced systems for nuclear safeguards. He is currently Assistant Division Leader for Safeguards and Security in the Energy Division and Program Manager for Safeguards and Security.

Shipley came to Los Alamos in 1966 to do instrumentation development in the Electronics Group. In 1973 Shipley assumed joint positions in the E-Division Research Group and as Alternate Group Leader of the Analog Instrumentation Group. During this time he pursued research, development, and design of instrumentation and control systems, including those for solar heating and cooling of buildings. In 1976 Shipley joined the nuclear safeguards program and was instrumental in setting up the systems group.

Shipley contributed Chapter 4, entitled "Decision Analysis for Nuclear Safeguards," to the book, Nuclear Safeguards Analysis: Nondestructive and Analytical Chemical Techniques. He is a past member of the editorial board of the Review of Scientific Instruments. Shipley is a member of the Institute of Electrical and Electronics Engineers, the American Association for Advancement of Science, the Institute of Nuclear Materials Management, and the scientific honorary society, Sigma Xi.

STATEMENT OF DR. JAMES P. SHIPLEY, JR., PROGRAM MANAGER, SAFEGUARDS AND SECURITY, LOS ALAMOS NATIONAL LABORATORY

Dr. **Shipley**. Thank you, Madam Chairman and members of the subcommittee.

It is a pleasure and an honor to be here to discuss with you at this time the topic of technical aspects of nuclear nonproliferation and safeguards. I do have a written statement for the record. I believe you have a copy of that.

Mrs. **Bouquard**. We have your prepared statement. You may summarize or proceed as you wish, and your complete testimony will be made a part of the record of this hearing.

Dr. **Shipley**. Thank you, Madam Chairman.

In view of your opening statement yesterday, and the fact that safeguards can be divided into two areas of application—that is, domestic and international—I would like to spend just a moment talking about the differences between those two. First of all, domestic safeguards do in fact have the objective of preventing a theft or diversion of nuclear material. The threat there is a subnational one. To achieve those goals, domestic safeguards make use of physical protection, materials accounting, and materials control. As we heard yesterday, the DOE is responsible for the weapons complex in terms of safeguards, and the NRC is responsible for commencial facilities.

In contrast to that, international safeguards do not have a direct prevention role—and I will come back to this point in just a moment—but they have a role of detection first and deterrence second. They do have a materials accounting element, but they have no physical protection element, that analogous function being taken up by something called containment and surveillance, as I think you are aware.

Generally speaking, the role of the IAEA is one of verification. In this case the threat to be defended against is the host nation. As Congressman Wolpe correctly stated yesterday, our goal ultimately is the prevention of diversion of nuclear material to nonpeaceful purposes. However, we must use the word "our," I think, advisedly. When we say "our," we are talking about the world community whose objective is, in fact, to prevent the diversion of nuclear material. As an instrument of that objective we have created the IAEA and endowed them with two functions, that is, detection and deterrence.

This means that there is one common element in all of safeguards, both domestic and international, and that is materials accounting. The Los Alamos safeguards program is directed to benefit both of those areas because they are common.

At this point I would like to consider some of the issues that were raised by the subcommittee directly, the first of those being the adequacy of present NDA equipment in both domestic and international safeguards. For the last 15 years or so, the Los Alamos National Laboratory has been doing development work on FDA equipment of various types. Generally speaking, the NDA equipment for the IAEA applications must be portable because that is the environment the inspectors find themselves in. On the other hand, sometimes we can build larger and more sophisticated devices for domestic safeguards.

The NDA equipment supplied to the IAEA in the last 5 years has been developed under the POTAS program, which you have heard discussed before, to support IAEA safeguards. In general this equipment has been high quality, reliable, easy to operate, and supplied in adequate quantity. We still have some problems, and I will discuss some of those a little later on. You will find them also in the written statement.

Next is the scope, effectiveness, and cost of the Los Alamos safeguards R&D program. As you know, our primary sponsor in this activity has been the Department of Energy's Office of Safeguards and Security. In fact, we have been engaged not in just NDA measurement device development but also in complete materials accounting systems as well. These materials accounting systems have been applied and are being applied to DOE facilities, in the IAEA arena, and in exchange programs with the United Kingdom, Japan, the Federal Republic of Germany, the Joint Research Center at Ispra, Italy; a number of activities are going on all around the world.

In addition, we have participated in something called the Allied-General Nuclear Services Barnwell Plant mini-run experiments, which have occurred in a series of seven over the last 2 years or so. I think you will hear some more about those later on from Mr. Buckham.

I believe the ultimate effectiveness associated with the safeguards program at Los Alamos can be measured by the requests for assistance that we have had from various members of the community of safeguards. We teach a number of schools every year, in fact, nine of those, including both domestic people from the safeguards community in the United States as well as those from the IAEA. In addition we are the primary host for the Nuclear Nonproliferation Act course, which is taught once a year, and we teach a series of both domestic and international safeguards schools on specialized topics as well, as the need arises.

Total cost of the Los Alamos safeguards program is approximately $10.3 million; $9 million of that comes from the Office of Safeguards and Security, $800,000 comes from the POTAS program, and $500,000 comes from the NRC. That comprises approximately 100 people working with safeguards at Los Alamos.

The next topic is coordination with other agencies and departments and/or nations. I have already mentioned many of those interactions. In addition to those, we also cooperate and interact with the Arms Control and Disarmament Agency, the Department of State, and other national laboratories such as Sandia, Oak Ridge, Livermore, Brookhaven, and so forth.

Our IAEA interactions are extensive. We participate in many working, consultant, and advisory groups. A good example of that is the international working group on reprocessing plant safeguards, to which we sent two representatives during the tenure of that working group.

What are some of the problems associated with having advanced safeguards techniques implemented in the field? As you will see from my written statement, I have divided those problems up into two classes, one being technical, the other being institutional. I will not go over them in detail here except to call your attention to two of them, the first being the last one listed in the technical problems, which has to do with the integration of the elements of safeguards—that is, containment/surveillance and materials accounting in the international context—into a system. Sometimes we tend to think of these elements as being separate entities that can be worked on without regard to the others. That is hardly ever true. They must be integrated in some coherent fashion. The techniques for doing that integration are still being developed.

Under institutional problems, one I would call your attention to is one that has been mentioned, I think, in these hearings before, and that is in the increasingly evident use of plutonium, or nuclear materials in general, in nuclear power and the concomitant emergence of nuclear facilities handling bulk quantities of nuclear material. It is going to be difficult if not impracticable for the IAEA to field the kind and the type of manpower to do an adequate job of safeguards, for these facilities.

What that says to me is that we must upgrade the technology to the extent that the inspectors can be freed from doing those onerous tasks that are not the best thing that they do. Inspectors are best at making subjective judgments, doing investigations, and so forth and I think we have to give them time to do that. That will require significant changes in the methods that the IAEA uses in doing their inspections, and it will require a change in the programs that support the development of safeguards at the IAEA. I believe making those changes to be one of the most substantial problems that we will have to face in the coming years.

What about long-range plans? We of course will continue the thing that we do best, that is, technology development. We are going to try to stay cognizant of the needs, which means that we have to work very closely with the operations side of safeguards, that is, those who are in the field and know what the real problems are. We accomplish that, I think, by continuing with training schools, workshops, seminars, and getting our own people out into the field as IAEA inspectors to participate in actual situations.

In summary, we are doing the best we can to provide good safeguards for both domestic and international facilities. We are not satisfied with the state of safeguards nor, I think, should we ever be. However, I do believe we have made substantial improvements in the last few years. In the interim we are going to continue to do the best we can to make safeguards even better and better.

I would be glad to answer questions at this time.

[The prepared statement of Dr. Shipley follows:]

STATEMENT OF

DR. JAMES P. SHIPLEY
ASSISTANT DIVISION LEADER/PROGRAM MANAGER
SAFEGUARDS AND SECURITY
LOS ALAMOS NATIONAL LABORATORY

Before The

COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
U.S. HOUSE OF REPRESENTATIVES

August 4, 1982

TECHNICAL ASPECTS OF NUCLEAR SAFEGUARDS

Madame Chairman and members of the Committee, it is a pleasure and an honor to be here to discuss with you the "Technical Aspects of Nuclear Non-Proliferation: Safeguards." The field of nuclear safeguards can be divided into two areas of application: domestic safeguards and international safeguards. Although much of the substantial body of safeguards technology is applicable to both areas, the problems and objectives of domestic and international safeguards are sufficiently different to merit closer examination in light of the five questions posed by the House Subcommittee on Energy Research and Production.

US domestic safeguards are designed to prevent the theft or diversion of special nuclear material (SNM) by a subnational-level effort, either terrorists or knowledgeable insiders, or perhaps combinations of these, working overtly or covertly. The three main elements of domestic safeguards are physical protection, materials accounting, and materials control. Physical protection comprises guards, barriers (e.g., fences and walls), surveillance devices, etc., that provide (1) control of personnel access to locations containing SNM, (2) detection of unauthorized movements of SNM to and from those locations, and (3) response to safeguards alarms. Materials accounting is based on measurements of all significant SNM flows and inventories and periodically drawing a materials balance to ascertain that all SNM is present that should be. Materials accounting gives the necessary assurance that the physical protection system has been successful (or not, as the case may be), as well as providing an additional capability for detecting SNM theft or diversion. Materials control is closely related to materials accounting in that it seeks to ensure that activities associated with SNM processing are the correct ones and that the locations of SNM are known at all times. In the US, the Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC) are responsible for safeguarding DOE facilities and commercial facilities, respectively.

In contrast, international safeguards, which are the responsibility of the International Atomic Energy Agency (IAEA), have no direct prevention function. Rather, IAEA safeguards are designed to detect diversion of SNM from peaceful uses and to deter that diversion by the risk of early detection. Furthermore, the IAEA's potential adversary is the host nation. Consequently, IAEA safeguards have a materials accounting element but no physical protection element. However, a monitoring role is played by the international safeguards measure known as containment and surveillance. This role is deemed to be complementary to that of materials accounting, which is considered to be of fundamental importance. The IAEA's materials accounting activities are intended to be a verification of the results of the State's system of accounting and control.

The basic differences between domestic and international safeguards are highlighted by the underlined words above and by recognizing the different adversaries. International safeguards are meant to detect and deter diversion by a host nation using monitoring and verification techniques, whereas domestic safeguards are aimed at preventing theft or diversion by a relatively small group.

The common element in domestic and international safeguards is materials accounting, although the two applications make slightly different use of the methods. Consequently, much of the Los Alamos Safeguards Program benefits both areas. With these thoughts in mind, consider the five issues raised by the Subcommittee.

- Adequacy of the present non-destructive assay equipment, and containment and surveillance devices being used domestically and by the International Atomic Energy Agency.

The Los Alamos National Laboratory has been designing, building, and implementing instruments and equipment for the nondestructive assay (NDA) of uranium and plutonium for about fifteen years. Typically, portable, easy-to-operate equipment has been supplied to the IAEA for field inspections, whereas larger, more sophisticated in-plant equipment has been supplied for domestic use. For controlled measurement situations, such as fuel rods with well-defined geometries and material densities, NDA equipment can make high-precision assays (1%). For less well-defined situations, such as scrap and waste materials where container geometries and material densities are variable, measurement quality is poorer but often still adequate for effective materials accounting. In addition, measurement of such materials by NDA may be more accurate and faster than by destructive analyses because NDA does not experience the sampling problem; that is, the entire item is measured, not just a small sample.

Portable NDA equipment provided to the IAEA in the past five years by the United States under the Program of Technical Assistance (POTAS) to IAEA Safeguards, in general, has been of high quality, reliable, easy to operate, and supplied in adequate quantity. The major difficulties encountered by the IAEA in the application of this equipment are (1) the development of assay procedures for the wide variety of nuclear materials -- sizes, geometries, densities, compositions -- that are found worldwide; (2) the availability of appropriate physical standards for calibration of the equipment; and (3) adequate training of IAEA inspectors in the proper use of the equipment.

Much of the existing effort on containment and surveillance R&D is aimed at physical devices such as seals and cameras. A greater effort is needed in the area of radiation-sensitive instrumentation for monitoring and verifying the movement of nuclear materials.

- Scope, effectiveness, and cost of your laboratory's R&D programs to develop new or improved safeguards equipment and techniques.

The safeguards R&D program at Los Alamos is primarily sponsored by the DOE/Office of Safeguards and Security (DOE/OSS) and is directed toward designing, developing, demonstrating, and implementing nuclear materials control and accounting (MC&A) systems and instrumentation, providing assistance in upgrading materials measurement and accounting procedures in domestic nuclear facilities, providing MC&A technology support for international safeguards, and developing and maintaining centers of excellence in computer and operations security for OSS.

Example activities under this program include the development and field testing of new NDA instruments for DOE facilities such as the Oak Ridge Y-12 Plant, and for application to nuclear materials assay proplems encountered by IAEA inspectors; the development of new data analysis methods to improve the sensitivity of nuclear materials accounting systems to losses of SNM; and the development of containment and surveillance methods for nuclear-facility vaults and portals.

The effectiveness of the Los Alamos safeguards R&D program can best be measured by the acceptance of the developed instruments and MC&A methods in the domestic and international safeguards community. Los Alamos is sought out to provide consultation and support in MC&A safeguards systems design; to provide prototype NDA instruments; and to provide instrument designs to commercial vendors, who have produced approximately a dozen different types of instruments for sale to the nuclear community. We have had ongoing interactions with the international safeguards community through the IAEA and a number of bilateral agreements that have ranged from consultation to direct transfer of safeguards technology to foreign users.

The FY 1982 budget for safeguards R&D activities at Los Alamos totals approximately $10.3M, with $9M provided by DOE/OSS, $0.8M from POTAS funds, and $0.5M from the NRC.

- Extent to which your laboratory's programs are coordinated with programs in other agencies and departments, as well as with other nations through existing technological agreements.

The Los Alamos National Laboratory safeguards programs are coordinated with other DOE programs through our interactions with DOE-OSS, the several DOE field offices, and nuclear fuel-cycle facilities. We interact with NRC programs through direct funding support. Our interactions with various foreign countries such as the UK and the Federal Republic of Germany, the IAEA, and the Commission of European Communities, are supported through DOE/OSS and include interaction with the Department of State and the Arms Control and Disarmament Agency. In addition, we participated heavily in the IAEA-sponsored International Working Group on Reprocessing Plant Safeguards.

Under POTAS, which is sponsored by the State Department, there is a very high level of interaction and cooperation with the IAEA and with various member states. In various bilateral agreements under the DOE program, we interact directly with safeguards R&D and inspection personnel in many countries, especially in Europe. Under the Tokai Advanced Safeguards Technology Exercise (TASTEX) program, there was considerable cooperation between Japan, France, the IAEA, and the United States.

Through our safeguards training courses, which are attended by about 200 people each year, we interact with personnel from the nuclear industry, various government agencies (DOE, State, NRC, the national laboratories), and many other nations.

- Problems being encountered in getting advanced safeguards equipment and techniques into routine use domestically and by the International Atomic Energy Agency.

Major problems encountered in getting advanced safeguards equipment and techniques into routine use can be divided into two classes, technical and institutional. The following list is approximately in order of increasing difficulty and, to a lesser extent, increasing importance and scope.

Technical:

a. Lack of detailed assay procedures for the wide varieties of nuclear materials -- sizes, shapes, densities, compositions -- found worldwide. Good safeguards depend on tailoring instrumentation to these characteristics. Therefore, the number of types of instruments required is large, but the number of each type is relatively small, which aggravates some of the following problems.

b. Lack of proper physical standards for calibration of equipment. Standards are essential to safeguards measurements, but the varieties of SNM, and the associated measurement equipment, require many sets of standard SNM quantities that are costly to prepare and maintain and difficult to support.

c. Limited availability of specialized equipment from vendors. The market for safeguards equipment is relatively very small, especially for some of the highly specialized instruments. Therefore, commercial vendors are reluctant to venture into an area where the potential profits may be severely limited.

d. Inability of vendors to follow through after selling and installing equipment. Safeguards equipment, like any other, requires periodic maintenance and occasional upgrading, which are difficult because, among other things, of the widespread locations of nuclear facilities and the sensitive nature of the applications.

e. Insufficient knowledge and training of personnel who operate the equipment. Some types of equipment require complicated procedures for operation and some knowledge of nuclear physics for proper application and data interpretation. The gap between inspector capability and equipment human engineering must be narrowed significantly.

f. Lack of integration of various safeguards subsystems, such as materials accounting and physical protection, into a complete safeguards system. Too often, these subsystems are considered to be independent and perhaps redundant. They are not. The most effective safeguards system uses these elements in a complementary fashion. Techniques for doing this integration are still under development.

Institutional:

a. Lack of awareness of and interest in the available technology. We must keep in mind that the raison d'etre for nuclear facilities is not safeguards but SNM processing. Consequently, an effective safeguards program necessarily incorporates a strong educational activity focusing both on safeguards technology and on the potential benefits to the facility, which can be significant.

b. Inability to convince safeguards practitioners of the practicality of some new ideas. The lack of demonstrations of advanced techniques in operating facilities exacerbates this problem. Nuclear facilities are based on complex chemical and physical processes that have evolved through sometimes painful experience. Facility operators are loathe to disrupt those processes to try new, untested safeguards technology that may be of uncertain benefit.

c. The need for closer interaction between safeguards R&D and operations personnel. This interaction is the best, if not the only, way to assure that R&D addresses real needs and that operations uses the technology. Any insulation between these two efforts, which tends to occur more than we would like partly because of the problems described above, can only contribute to the opposite outcome.

4. In the future, the IAEA's safeguards responsibilities for large, bulk-handling facilities will increase. At present, the IAEA would be hard-pressed to field either the type or quantity of inspection effort required to safeguard those facilities effectively using current techniques. I believe that any safeguards effort for such facilities that is manpower-intensive will necessarily be impracticable and expensive.

   One possible solution is to design the safeguards technology so that the inspectors are much less burdened with time-consuming chores that are unimportant from the viewpoint of the ultimate result. This step would free the inspectors to do those things that they do best: investigate anomalies, make subjective judgements, etc.

   However, this solution will necessitate significant changes in the way international safeguards are done and in the programs that support them. Making these changes is perhaps one of the most substantial problems to be encountered in the next few years.

- Your laboratory's long-range plans for improving domestic and international safeguards equipment and techniques.

Los Alamos National Laboratory's long-range plan corresponds to the two types of problems identified above. Technical problems obviously can be addressed through proper application of the Laboratory's resources, which is a continuing process. However, the more significant problem is recognizing the technical capabilities and needs, which can only be done by means of close interactions among the safeguards R&D community and those responsible for implementation and operation of safeguards in the field. This approach, based on training courses, workshops, written material, personal contacts, and demonstrations in operating facilities, forms the essential basis for addressing the set of institutional problems identified above.

In summary, we are doing the best we can to assure the availability and application of effective safeguards technology, both domestically and internationally. We are not satisfied, nor should we ever be. We are continually working to make these safeguards systems, which have improved substantially in the last few years, better and better.

Mrs. BOUQUARD. Thank you very much, Dr. Shipley.

We are happy that the ranking Republican member of this committee is with us, Congressman Lujan, and we welcome you for any additional comments you might like to make at this time.

Mr. LUJAN. Thank you, Madam Chairman.

I did have an opening statement and I would ask unanimous consent to revise and extend immediately following your comments.

Mrs. BOUQUARD. Without objection, your remarks will immediately follow.

[The opening statement of Mr. Lujan follows:]

Opening Statement
The Honorable Manuel Lujan, Jr.
5th Hearing on Technical Aspects of Nuclear Non-Proliferation
August 4, 1982

Thank you, Madam Chairman. Yesterday, we heard from some very interesting witnesses. I was struck by the point that there are differing definitions of safeguards, and that the problems of international safeguards are very different from the problems of domestic safeguards. Although both international and domestic safeguards have a materials accounting aspect, international safeguards focus on containment and surveillance while domestic safeguards focus on physical security. Domestic safeguards are concerned with plant safety, conspiracy, and transportation of nuclear materials. It is important to remember these differences when evaluating the safeguards systems and their implementation.

A main purpose of these two hearings is to examine the interrelationship of the safeguards technology and its actual use -- not only by the IAEA but domestically and its adoption by other countries as well. The research and development programs at the three national laboratories (that we will hear from today) and at industry (represented also by two witnesses today) are a crucial link in ensuring nuclear non-proliferation. I have observed that the safeguards community is effective, certainly in part because of the close cooperative working arrangements they have developed. I look forward to hearing from our witnesses today. I especially want to welcome the two witnesses from my home state, Dr. William Myre from Sandia National Laboratories and Dr. James Shipley from Los Alamos National Laboratory.

Thank you, Madam Chairman.

Mrs. BOUQUARD. Dr. Kouts, if I am correct, POTAS was begun during the Ford administration to help improve safeguards systems where normal IAEA budget channels could not respond fast enough. In your statement you also said that equipment is supplied by POTAS to IAEA, and that the movement of this equipment from test to evaluation to application has been too slow.

Since we formulated POTAS to correct this inequity, what do you see as the major problems? Is it an IAEA resource problem, or is POTAS not moving fast enough? Is IAEA accepting the recommendations and the equipment supplied by POTAS?

Dr. KOUTS. I think the principal problem is one that might be expected just because IAEA is a bureaucracy, and in fact it is an international bureaucracy. An international bureaucracy is even more slow to respond to changes than a domestic bureaucracy is.

It is difficult in an organization like IAEA, which has no strong command and responsibility structure, to make sure that the objective is kept in mind at all times in a program of this kind. Different people are involved in receiving equipment, in testing equipment, in judging the equipment, and finally applying the equipment in the field. There has to be a transfer not only of responsibility for the equipment but a transfer of interest in the use of the equipment from each of these lines of people to the next. It is a slow process and it is one that the IAEA recognizes and is working very hard on but it is going to take a while to overcome.

Mrs. BOUQUARD. According to some of our officials, a significant achievement of POTAS has been the development of reliable and easy to use—and where required, tamper resistant—safeguards equipment. Would you agree with that statement?

Dr. KOUTS. Oh, yes. I would certainly agree with that statement.

Mrs. BOUQUARD. Well, since we have begun formal coordination of our assistance programs with those of other countries, what forums or mechanisms are you using for this formal coordination?

Dr. KOUTS. At the recent meeting of the Institute for Nuclear Materials Management here in Washington—that was about a month ago—representatives of all the various countries who have assistance programs of this kind met for the first time and agreed that from now on they would directly interact instead of interacting through the IAEA.

Mrs. BOUQUARD. What countries are involved?

Dr. KOUTS. Canada, the United Kingdom, the Federal Republic of Germany, Australia, Japan, and now incoming are France, the Soviet Union, and perhaps a few others. Representatives of these countries have really been interacting individually with the IAEA with respect to requests for work to be done and satisfaction of these requests and so on, without very much interaction among themselves to see that duplication is avoided or that gaps are not left in what the IAEA requires.

They agreed that they would begin periodically to meet and to discuss among themselves what their programs are, to make sure that duplication does not occur, and things are not left out in the future. It is something we have wanted to happen for a long time and I am glad it is happening.

Mrs. BOUQUARD. Well, you said that Dr. Higinbotham identified an IAEA equipment requirement of about $20 million over the next few years. What is the most pressing need at the present time in equipment for IAEA?

Dr. **Kouts**. The most pressing—I do not know that he actually rated things in terms of priorities. He simply listed what was required as a function of time and established a plan for IAEA to acquire equipment that would be required to meet the needs that would appear year-by-year in the IAEA's program. In my mind, however, the most pressing requirement is unattended, tamperproof surveillance equipment. The IAEA has equipment of this kind on hand. It is not really satisfactory at present. It is equipment which they purchased from a foreign source some years ago. We now have equipment to replace this in the pipeline and the most urgent requirement, I think, is to supply this equipment which is needed in great amounts. It is going to be fairly expensive.

Mrs. **Bouquard**. Would you comment on ACDA's project for their remote continuous verification system, RECOVER?

Dr. **Kouts**. Which project is this?

Mrs. **Bouquard**. Their project RECOVER, their remote continuous verification system.

Dr. **Kouts**. Oh, RECOVER. Yes. Well, the RECOVER project is really a secure information transmission link at present, and it could have a number of kinds of applications depending on the kinds of instrumentation.

Mrs. **Bouquard**. Would it address the needs that you were referring to?

Dr. **Kouts**. Oh, no, not those needs. That is a different kind of system. What I am talking about is a television monitor system which records and can be called back later so as to find out what happened in the interim when the thing that is being surveyed was unattended.

Mrs. **Bouquard**. If the POTAS equipment was put into general use, would the inspectors be capable of using this equipment reliably without additional training?

Dr. **Kouts**. They always need additional training and this is part of the responsibility which Los Alamos has been so well discharging in its courses over the years. Every IAEA inspector goes through the Los Alamos courses on the use of this equipment, and most of the equipment which is used in this way is U.S. supplied equipment now so they get the full gamut of what they are going to meet in the field.

Mrs. **Bouquard**. Thank you very much.

Mr. Lujan? Then I would like to have additional questions for other witnesses.

Mr. **Lujan**. Thank you, Madam Chairman.

First of all, let me welcome you Dr. Kouts, and also two of my constituents from Los Alamos and Sandia, Madam Chairman, as you know those two laboratories are in the forefront of the security and safeguards business. We are very proud of them, so welcome.

Mrs. **Bouquard**. Mr. Lujan, I certainly expected those comments from you this morning. We welcome all of our national laboratories.

Mr. **Lujan**. We have to brag on our good points, Madam Chairman.

Yesterday we had some very fruitful discussions on the safeguards program, primarily international rather than within the United States. I would like for you all to comment on one of the comments that was made, that is: the international safeguards requirements are really different than our domestic ones. The international safeguards requirements are, to put it simply, an accounting function for the material. Domestically, we not only have the accounting function, but, in addition to that, the physical security and the transportation. Is that pretty much the situation, that we do not get into physical security and transportation and those kinds of things in the international safeguards program?

Dr. **SHIPLEY**. That is not quite correct. In fact, materials accounting is a measure of fundamental importance, to quote from Information Circular 153, which is a basic document of the IAEA. However, materials accounting is augmented with a complementary measure that is called containment and surveillance, which one might think of, I suppose, as being analogous to physical protection in domestic safeguards.

Mr. **LUJAN**. I cannot quite hear you.

Dr. **SHIPLEY**. I am sorry. Shall I start again?

Mr. **LUJAN**. No, I heard but I was having to strain.

Dr. **SHIPLEY**. All right.

The containment and surveillance activities that are the counterpart of physical protection have no response function in IAEA safeguards; that is, there is no force to respond to some sort of a safeguards breach that might be identified by whatever means, and that is the fundamental difference.

Mr. **LUJAN**. However, is the technology, or the types of safeguards programs, or at least the information available to other countries?

Dr. **SHIPLEY**. Certainly.

Mr. **LUJAN**. Is that basically it, rather than the response?

Dr. **SHIPLEY**. As a matter of fact, the IAEA does provide guidance to the member-States in terms of what kind of physical protection system might be required, and that guidance is indicated through Information Circular 225.

Mr. **LUJAN**. Is it pretty easy to transfer this technology to other countries through IAEA? Do we do it directly? Is it very difficult to do? What is your feeling?

Dr. **SHIPLEY**. I think any kind of technology transfer is always fraught with difficulties. With respect to your question concerning how it is done, it is done both through the IAEA and through bilateral agreements with other countries. I mentioned a couple in my statement. The Federal Republic of Germany is one. The Joint Research Center at Ispra is another. The TASTEX program is another. In all those I believe there is a continuing presence of the IAEA, so it is a mixture of interactions.

Mr. **LUJAN**. It would seem to me that we would not have the problem of technology transfer in the area of safeguards and equipment for safeguards that we do in other areas. Do you find it a little easier in the safeguards area?

Dr. **SHIPLEY**. I am not quite sure what you mean exactly by "technology transfer." I will say that we have little difficulty transferring the technology to the safeguards community in other nations. They are very willing to discuss these things and to work with us on various bilateral programs.

However, as was mentioned yesterday by Mr. Caudle in his statement, facility operators have developed the complex processes in nuclear facilities through a long and painful process. Sometimes they are a little reluctant to disrupt those processes for a safeguards activity that might be of uncertain benefit.

Mr. LUJAN. We will have as one of the later witnesses Dr. Buckham from Allied-General Nuclear Services [AGNS]. One of the things that I have always been concerned with is the use of Barnwell. As you know, what we have been doing there is using it as a safeguards laboratory. Do you think that effort is worth it? Is it a good program that we have going there?

Dr. SHIPLEY. Yes, sir, I do.

Mr. LUJAN. Do you have a lot of interface with them?

Dr. SHIPLEY. Very much so. We have done, as I indicated, over the last 2 years a series of seven of these so-called mini-run experiments, and we have participated heavily in all of them along with Oak Ridge and AGNS people.

Mr. LUJAN. Has Sandia?

Dr. MYRE. I would agree with that statement. We have had a long and very fruitful cooperative program with them in physical protection, and we have enjoyed it very much and think it has been of great benefit to the United States.

Mr. LUJAN. What about Brookhaven?

Dr. KOUTS. We have interacted quite extensively with the AGNS program as well, and I would certainly reinforce any view that AGNS has been extremely useful in this regard. As a matter of fact, in recent years this has been one of the very few means we could use with respect to chemical reprocessing to help influence the course of the Agency's activities. It has been absolutely essential for that.

Mr. LUJAN. What about interface with NRC regarding the design of facilities and use of all of the safeguards methods? Does that pretty much work hand-in-hand, that as soon as some method is developed, it is built right into the design of powerplants?

Dr. MYRE. Yes. In my statement I discussed the various methods that have been generated under NRC sponsorship, and those have been used not only by NRC licensees but by DOE facilities, and in fact by some DOD programs as well.

Mr. LUJAN. Well, I am sorry I was late. Around here you always have two or three meetings going at the same time and I was over in Interior helping them open that one up, and then moved on to this one.

However, I do have one final question about something that intrigued me yesterday, and that was the remote monitoring—and I know you must have talked about it in your statements, or at least I did hear some mention as I came in late. At some point can we look forward to having adequate monitoring by remote means? Part of the testimony yesterday was that some of the countries have a lot of difficulty—or maybe not a lot—some difficulty, I should say, in resident inspectors. Maybe the two countries do not get along or for some reason they do not want a particular inspector there.

One question they could not answer yesterday because they are not in the same hands-on work that you are. Can we look forward to most of the monitoring being done remotely in the future? What is your feeling about that?

Dr. MYRE. My own perception is that remote monitoring will enhance the capability of the inspector by a tremendous amount. However, I do not think it will do away with the inspector presence at the sites but it will enable him to be much more efficient.

Mr. LUJAN. What you are saying is, put the instrumentation in and then the inspector can look at the gauges?

Dr. MYRE. Yes, and so he will be able to handle more facilities in a much easier way. But I do not think it will do away with the inspectors—it will not become automated to the point that the inspectors are not necessary.

Mr. LUJAN. Does IAEA require a resident inspector at every plant?

Dr. MYRE. My understanding is no, that he just visits. Certain kinds of facilities the IAEA is discussing having resident inspectors but at most not.

Dr. KOUTS. That is true.

Mr. LUJAN. May they not require a resident inspector, like at a generating plant?

Dr. KOUTS. Resident inspectors at present are not really required at any plant but there is discussion about requiring them in the future at special plants that have specific safeguards problems attached to them.

Mr. LUJAN. That is different than our domestic program. We are moving to having a resident inspector—am I correct?—at every location.

Dr. KOUTS. No, not in safeguards. In safeguards it is still a rare thing in this country. We are moving toward having resident inspectors for safety at some plants, some nuclear powerplants, but not in safeguards.

Mr. LUJAN. Not in the safeguards area. OK.

Thank you, Madam Chairman.

Mrs. BOUQUARD. Thank you very much, Mr. Lujan.

Dr. Myre, what were the results of the study of the feasibility of applying an integrated containment and surveillance system in the fuel receiving and storage areas of the Tokai Mura Reprocessing Plant? Is this feasible?

Dr. MYRE. Yes, ma'am, it is feasible and I think in general the feeling is, as Dr. Shipley has said, that the combination of containment and surveillance and material measurement and accounting systems, if you combine the two in intelligent ways it becomes the most cost effective system. We have not looked at anything that was not feasible. In some of the bulk handling plants it is difficult and will cost a fair amount of money but it is feasible in every study that we have performed.

Mrs. BOUQUARD. What other countries participated in the TASTEX program?

Dr. MYRE. France, Japan, the IAEA, and the United States, I think that is right.

Mrs. BOUQUARD. Did we contribute equipment for surveillance and monitoring at the Tokai Mura Plant?

Dr. **Myre**. Yes, we did install some equipment there as part of that experiment.

Mrs. **Bouquard**. Dr. Myre, you stated that the GCEP studies have resulted in conceptual containment and surveillance systems for inspection strategies that allow inspectors to have access to the cascade area as well as strategies that prohibit inspectors access to these sensitive areas. Have we moved beyond the conceptual stage for such systems as GCEP?

Dr. **Myre**. Yes, ma'am. One of the technical devices that we are thinking about is a robot inspector that can be pushed around through the plant, and it measures what is in the pipes close to the robot and it would not have to be accompanied by an inspector but would know by a guidance system where it was.

Mrs. **Bouquard**. The robot cannot tell what it saw.

Dr. **Myre**. Yes, other than the instruments that are part of the robot, which are known and approved by the plant.

Mrs. **Bouquard**. Very fine. Therefore, we are actually working on the hardware so that we will be ready when the plant is operable. Is that correct?

Dr. **Myre**. Yes, ma'am.

Mrs. **Bouquard**. How much influence do the DOD program managers have in the direction of the safeguards R&D that is being conducted at Sandia?

Dr. **Myre**. I believe the DOD program managers have complete influence on how their programs go. Sandia's role is provide a technology base for them to draw upon to be able to design their security systems——

Mrs. **Bouquard**. The question that I am asking is, what is the extent of the DOD program managers influencing the decisions that you make?

Dr. **Myre**. We learn from them what their problems are and utilize their results to feed into our technology base to see the kinds of areas that we need to be working on. In many cases the DOD problems of securing their bases are very similar to the DOE's or the NRC's problems of protecting their facilities, and so we look at their input requirements as a basis for generating our technology base program.

Mrs. **Bouquard**. Do you think that there is an overlap in this area, or do you think that it is worthwhile that DOD is directly involved?

Dr. **Myre**. Oh, I think it is very worthwhile because the problems are so similar that we end up with just one technology base addressing all these areas in protection of nuclear materials.

Mrs. **Bouquard**. Thank you very much.

Dr. Shipley, you said that you participated heavily in the IAEA-sponsored International Working Group on Reprocessing Plant Safeguards. Would you comment further on this group? Is it still active?

Dr. **Shipley**. No, ma'am. It terminated last September. The period of the working group I believe was from approximately January 1979 through January 1981 and then it was extended at the last moment through September. The working group was comprised of members from various countries, notably the United States, the United Kingdom, the Federal Republic of Germany, France, and Italy. India also had participation on occasion, and there were various others.

The International Working Group on Reprocessing Plant Safeguards was designed to look at the possible application of advanced safeguards techniques to reprocessing facilities. To accomplish that goal, it was divided into four working groups, one on facility design criteria to facilitate safeguards, one on data generation and evaluation for safeguards, one on containment and surveillance, and one on advanced systems of evaluating materials accounting systems.

Mrs. **BOUQUARD.** Does that relate to measurements?

Dr. **SHIPLEY.** It relates to both measurements and to the application of containment surveillance measures to assure the integrity of the measurements.

Mrs. **BOUQUARD.** What measurement technology improvements would provide the maximum increases in materials accounting system performance? Do we have all the science in hand?

Dr. **SHIPLEY.** The measurement techniques that are available to us at the current time very closely span the wide range of materials that exist in the current nuclear fuel cycles and those that are likely to exist in the near future at least. That will not quite be true with some other possible fuel cycles but the techniques are known and only need to be developed. As was indicated yesterday, I think it is now a matter of doing the engineering and transferring those techniques from a laboratory to an operating field situation. That is where the most important difficulty lies.

Mrs. **BOUQUARD.** Dr. Shipley, you also mentioned the limited availability of specialized equipment from vendors. Are we developing much of this equipment in-house or do we let contracts to vendors to develop it? What can we do to encourage more vendor participation?

Dr. **KOUTS.** The initial devices usually are developed in-house—that is, in the laboratories—because they have the expertise and the resources to do that development. As soon as possible and practicable we try to transfer any further construction of those devices to a commercial organization of some kind. In fact, there have been on the order of a dozen of those kinds of transfers made in the last few years. Generally speaking, we try not to do any more than a few prototype device types of development in the laboratories, to get to the point where we can say that we are comfortable with the idea, that the instrument is in the field and working properly and might be applied in the correct way by the inspector. At that point it should be commercialized.

Mrs. **BOUQUARD.** However, at the inception state it is the work of the national laboratories. Am I correct?

Dr. **KOUTS.** Yes, that is correct.

Mrs. **BOUQUARD.** Including the work that you do for NRC and DOE and the POTAS program?

Dr. **KOUTS.** Yes, for each one of these applications. Safeguards for light water reactors are probably the easiest to take care of. If you are concerned about the possibility that someone might steal fissile material to make a nuclear weapon, probably you would not spend most of your attention watching the light water reactors because that is one of the hardest routes to go. The infrequent inspections that the IAEA applies to the light water reactors are probably quite adequate to take care of this question. Along the lines that Dr. Shipley mentioned, there are still requirements for transferring some of the technology into field operation which we have to take care of but the methodology is there and I feel quite comfortable about that.

The greatest difficulty would certainly be attached, of all the plants you have mentioned, to chemical reprocessing plants. Chemical reprocessing plants have not been built, commonly, with safeguards in mind, and it takes an intimate knowledge of the structure and operation of a chemical reprocessing plant to be as sure as one might like to be that everything is progressing properly. If you design the plant with safeguards in mind, the problem becomes much simpler and I think that in the future if we really want to make sure that these problems are properly taken care of, we will watch them from the outset and make sure that the design makes safeguards straightforward and reliable. If we do that, then I think the methodologies that we have in mind, the methodologies that we have in hand, are capable of taking care of all of these problems.

Mrs. **Bouquard**. Therefore, we need the application of the methodologies that we have?

Dr. **Kouts**. From the beginning, yes.

Mrs. **Bouquard**. Very fine.

Dr. Myre?

Dr. **Myre**. I would agree with what Dr. Kouts said. I would just like to add to that, I think this points out the value of the work that we have had with the Barnwell activity because that does allow us to get hands-on experience with safeguards in a fairly large reprocessing plant.

Mrs. **Bouquard**. Dr. Shipley?

Dr. **Shipley**. I also have to agree. You hear the same story from all of us, I suppose. I think that one has to worry about those things too. I would also like to emphasize the need, as Dr. Kouts pointed out, to have these safeguards considerations brought into play at the earliest possible moment. It is extremely important, I think, that these facilities be designed in the beginning with safeguards in mind. I do not mean to say that safeguards should drive the design in any way that might be disruptive of the process, because that will not work in the end but we certainly need to be figuring in the early design of these facilities.

Mrs. **Bouquard**. Thank you, gentlemen, for your very excellent testimony. We will have additional written questions from members of this committee that were unable to be with us this morning, and I would ask that you respond to them for the benefit of this committee.

Our next panel includes Dr. James Buckham, President of Allied-General Nuclear Services, and Dr. Roy Nilson, Manager of Corporate Licensing of Exxon Nuclear Co. We welcome you to our hearings this morning.

Dr. Buckham is accompanied by Karl Bambas, whom we also welcome. Dr. Buckham, would you please proceed with your testimony?

[A biographical sketch of Dr. Buckham and Mr. Bambas follows:]

J. A. Buckham

Dr. James A. Buckham is President of Allied-General Nuclear Services. He obtained his Ph.D. in Chemical Engineering from the University of Washington in 1953, preceded by an M.S. degree in 1948 and a B.S. degree in 1945 from the same institution.

Dr. Buckham has overall responsiblility for activities of AGNS and the Barnwell Nuclear Fuel Plant.

Dr. Buckham has been a leading figure in the development of nuclear reactor technology, the reprocessing of irradiated nuclear fuels, and the management of nuclear wastes. He is probably best known for his R&D work on the application of fluidized bed technology to the solidification of high-level radioactive waste and for the development and operation of several new dissolution processes for irradiated reactor fuel elements.

Prior to joining AGNS in 1976, he was Assistant General Manager of DOE's Idaho Chemical Processing Plant for Allied Chemical Corporation. In this capacity, he directed operation of the Idaho Chemical Processing Plant, development of reprocessing methods for new HTGR, rocket and Navy fuels, operation of the Waste Calcining Facility and development of advanced designs of waste management facilities, operation of the Krypton Recovery Plant and development of advanced recovery concepts, and operation of laboratories serving all contractors at the National Reactor Testing Station.

From 1961-1971, Dr. Buckham undertook projects including large-scale demonstration of pot calcination, chop-leach processing of nuclear fuel, and Darex processing for stainless steel-contained fuels. In addition, he supervised engineering development work in fuel processing and waste disposal; reprocessing methods for nuclear fuels; and treatment of radioactive wastes, nuclear reactor decontamination and other chemical technology functions in the nuclear field.

Between 1953 and 1961, he was a member of a team engaged in the development of a process for continuous dissolution of nuclear fuels, supervised the planning and conducting of pilot plant studies of continuous dissolution and solvent extraction phases of nuclear processing, was coordinator for the Fuel Element Cutting Facility Project at ICPP, and supervised experiments on various aspects of nuclear fuel processing and fluidized bed calcination of radioactive wastes.

He is the author or coauthor of over 25 technical publications related to nuclear technology, nuclear fuel reprocessing, and radioactive waste management and is active in the American Institute of Chemical Engineers, the American Nuclear Society, American Chemical Society, and the Atomic Industrial Forum. In 1974, Dr. Buckham was awarded the Robert E. Wilson Award by the AIChE in recognition of his outstanding accomplishments. In 1976, he was elected a Fellow of AIChE, and in 1979 he was elected to a three-year term as Director. He is a member of the honorary societies Tau Beta Pi, Sigma Xi, Phi Lambda Epsilon, and Zeta Mu Tau.

Karl J. Bambas

Vice President and Acting Director, Safeguards.
B.S., Chemical Engineering, Syracuse University, 1955
M.S., Chemical Engineering, Syracuse University, 1957
MBA, Harvard University, 1960.

As Vice President, Finance & Administration, Mr. Bambas' responsibility includes control of the budgeting process, financial performance reporting, economic studies, and systems development. He also has responsibility for the Procurement and Material Control and the Records Management functions. Mr. Bambas has direct responsibility for the coordination of the DOE contract administration.

As Acting Director of Safeguards, Mr. Bambas is responsible for the Advanced Integrated Safeguards System (AISS) being developed by AGNS. The AISS will provide an in-depth defense against sabotage, theft, or diversion of plutonium or uranium from large capacity nuclear fuel plants.

Prior to joining AGNS, Mr. Bambas was a financial analyst with Union Carbide Corporation in New York. He was responsible for long and short range analysis and planning for the fiber and textile chemical areas for Union Carbide Corporation. After joining Allied Chemical Corporation in 1969, Mr. Bambas held various positions in capital budgeting, economic analyses, and analytical systems development. He managed financial analysis and financial planning sections while in the employ of Allied Chemical, and served as Division Controller, and later as Assistant to the President of the Specialty Chemicals Division.

Mr. Bambas' initial industrial experience was in the supervision of process operations for the manufacture of organic esters, plasticizers, food preservatives, and agricultural chemicals. He also managed the manufacture of fabricated urethane foam products for Union Carbide.

Professional organizations of which Mr. Bambas is a member include the Financial Executives Institute and the Institute for Nuclear Materials Management.

STATEMENT OF DR. JAMES A. BUCKHAM, PRESIDENT, ALLIED-GENERAL NUCLEAR SERVICES, ACCOMPANIED BY KARL BAMBAS, VICE PRESIDENT AND DIRECTOR, SAFEGUARDS PROGRAMS

Dr. **Buckham**. Madam Chairman and subcommittee members, my name is James Buckham and I am president of Allied-General Nuclear Services, which is the owner of the Barnwell Nuclear Fuel Plant. I am accompanied by Karl Bambas, our vice president and director of our safeguards programs. We greatly appreciate your invitation to discuss the safeguards development work at Barnwell this morning.

Your invitation asked that we provide certain specific information and we have included all of that in the complete statement, which we would ask to have entered into the record.

Mrs. **Bouquard**. We have your entire testimony and you may proceed if you wish to summarize, but your entire statement will be made a part of the record.

Dr. **Buckham**. Thank you, Madam Chairman.

Your invitation also said the subcommittee would welcome comments on additional items of significance, and I will include a few such comments in my summary statement this morning.

Mrs. **Bouquard**. We appreciate your additional testimony.

Dr. **Buckham**. At the outset I want to stress that the Barnwell nuclear fuel plant presents an outstanding opportunity for the United States to exert leadership in achieving international agreement on effective safeguards for reprocessing plants to prevent nuclear proliferation.

Through a program of cooperation with the national laboratories, a safeguards system has been installed in portions of the Barnwell plant which appears capable of accomplishing diversion detection goals which were previously believed unachievable. Tests to date show that this safeguards system is capable of performing a complete plant inventory once each hour and can detect diversions of as little as 100 grams of special nuclear material. This is a truly significant advance over current safeguards procedures, which not only require annual or semiannual shutdown and cleanout of the reprocessing facility but they also lack the quantitative sensitivity of the Barnwell system. In addition, a Barnwell-developed physical protection system using state-of-the-art technology can provide extremely effective controlled access to reprocessing facilities.

The Barnwell plant has been uniquely capable of developing this advanced safeguards system. It is a large, modern facility and is, in fact, the only large-scale commercial reprocessing plant in the United States capable of operation in this century. Its minimum-maintenance design drew heavily on the operating experience of the numerous Purex-type reprocessing plants, both domestic and foreign, which preceded it. Proven features of these plants were adopted in the Barnwell design. Conversely, features which had contributed to operating problems in earlier plants were eliminated or corrected. Independent and experienced experts have visited the Barnwell plant and have concluded that it is fully operable and maintainable and will easily meet all safety and environmental requirements.

In operation, the Barnwell plant could recover reusable fissile material which would produce electric energy equivalent to that from burning 1 million barrels of oil per day. Barnwell is thus also important to national energy conservation.

Of even more timely importance, Barnwell has the capacity to make a major contribution to the national nuclear waste management program, greatly reducing the volume of nuclear waste for long-term storage. Moreover, with removal for burning in reactors of the long half-lived plutonium, both the level of potential hazard and the period during which the waste material could be potentially hazardous would be reduced manyfold. Indeed, the administration has cited reprocessing as the foundation of effective nuclear waste disposal.

Construction of the Barnwell plant had been encouraged by longstanding U.S. Government policy. In 1977 that policy was abruptly reversed due to concern primarily that plutonium from reprocessing plants elsewhere in the world might be diverted to nonpeaceful purposes. Shortly thereafter the Congress—with, I might say, this subcommittee having a significant role in it—took actions to preserve the Barnwell plant as a major and unique asset of significant national and international importance. Since 1978, with congressionally authorized funding and under contract to the Department of Energy, the Barnwell plant has been utilized effectively in research, development, and demonstration activities in direct support of national energy and nuclear nonproliferation objectives. Safeguards have comprised a continually increasing portion of the Barnwell R&D program.

The modern, full-scale Barnwell plant is uniquely capable of allowing development and preliminary testing of advanced safeguards technology. The Barnwell-developed safeguards system features the latest in computer technology, process monitors, intrusion detection devices, and access control systems. Many of the national laboratories, capitalizing on advances they had previously made largely through work in defense programs, have been active participants in developing this new technology and in designing tests that were conducted at Barnwell. These include Los Alamos, Sandia, Oak Ridge, Brookhaven, and Lawrence Livermore National Laboratories, as well as the DOE-related Rocky Flats, Savannah River, and Hanford facilities.

Based on the results of tests to date, the Barnwell system has been widely acclaimed for its sensitivity, hourly inventory capability, and enhancement of operability. However, these tests have been conducted with only short runs and in only a portion of the plant. International acceptance will require a demonstration of effectiveness and operability through sustained—by that, I mean at least 2 to 3 month—operation utilizing all of the chemical separations components of the plant, and this has been proposed by the DOE for fiscal year 1983. This proposed complete plant run would demonstrate the entire, full-scale integrated safeguards system, including its computerized material accountancy and physical protection systems, patrol officer interactions, and the collection, processing, and display of information in the plant's safeguards coordination center.

Japan, Germany, France, and the United Kingdom are all planning to build in the near future reprocessing plants similar in size and operation to the Barnwell plant. Demonstration of the effectiveness of the Barnwell safeguards system could materially influence the level of safeguards at these and other plants which will follow throughout the world. As Dr. Kouts so eloquently said earlier, if this is done so that it can be incorporated at the design stage it is far superior to a retrofit later.

This, then, would be in complete harmony with the administration's nuclear nonproliferation policy, which calls for the United States to help provide for an improved international safeguards regime and reestablish the United States as a predictable and reliable partner for peaceful nucdear cooperation under adequate safeguards. Barnwell, then, can be an integral part of the administration's nonproliferation program, starting with the full-scale demonstration of its effective safeguards system as proposed for next year by the Department of Energy and as strongly endorsed by the International Atomic Energy Agency.

I thank you for your attention. Mr. Bambas and I would be pleased to entertain any questions.

[The prepared statements of Dr. Buckham and Mr. Bambas follow:]

STATEMENT SUBMITTED TO
THE SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
OF THE COMMITTEE ON
SCIENCE AND TECHNOLOGY
U. S. HOUSE OF REPRESENTATIVES

ON

SAFEGUARDS DEVELOPMENT PROGRAMS AT THE BARNWELL NUCLEAR FUEL PLANT

AUGUST 4, 1982

BY

JAMES A. BUCKHAM, PRESIDENT

AND

KARL J. BAMBAS, VICE PRESIDENT

ALLIED-GENERAL NUCLEAR SERVICES

Madame Chairman and Subcommittee members, my name is James A. Buckham. I am President, Allied-General Nuclear Services (AGNS), owner of the Barnwell Nuclear Fuel Plant (BNFP). AGNS is an equal partnership of Allied Chemical Nuclear Products, Inc. and General Atomic Company. I am accompanied by Karl J. Bambas, AGNS Vice President -- Finance and Administration. Mr. Bambas is also Director of AGNS Safeguards programs. We greatly appreciate your invitation to discuss the safeguards development work at Barnwell and its international significance.

Your invitation specifically asked that we provide a status report of the Barnwell safeguards development program, comment on a number of its specific aspects, and provide a detailed description of the Barnwell-developed Safeguards System. In doing so, it appears most efficient to begin with an introductory statement, and to then discuss the following requested topics: current domestic and international safeguarding procedures; problems foreseen in gaining acceptance of improved procedures; significant features of the Barnwell-developed Safeguards System; coordination with National Laboratories; and our thoughts on appropriate future actions. We have provided the requested detailed description of Barnwell safeguards activities as Appendix A.

INTRODUCTION

The BNFP is a modern, full-scale nuclear fuel reprocessing plant located in the Midlands of South Carolina. Its "minimum maintenance" design drew heavily on the operating experience of the numerous Purex-type reprocessing plants -- both domestic and foreign -- which preceded it. Proven features of these plants were adopted in the Barnwell design. Conversely, features which had contributed to operating problems in the earlier plants were eliminated or corrected. The panels of knowledgeable, experienced, independent experts who have visited the Plant and meticulously reviewed its design and construction have all agreed that the BNFP is fully operable and maintainable.

In operation, the Barnwell Plant could make important contributions to both energy conservation and effective nuclear waste management. The reusable fissile material which the Plant would recover could produce electric energy equivalent to that derived from burning one million barrels of oil per day. High-level waste, in chemically stable solid form, would occupy only one-tenth of the volume of the fuel assemblies from which it came, if the latter were to be discarded as waste. Moreover, with removal, for burning in reactors, of the long half-lived plutonium, both the level of potential hazard, and the period during which the waste material could be potentially hazardous, would be reduced manyfold. Indeed, the Administration has cited reprocessing as the foundation of effective waste disposal.

In addition, and perhaps of even more immediate interest to the Subcommittee, the Safeguards System which has been installed in the Barnwell Plant can make extremely important contributions to national nuclear nonproliferation objectives. Demonstration of this System on a sustained basis in Fiscal Year 1983, as proposed by the Department of

Energy, provides the opportunity for the United States to exert leadership in achieving international agreement on effective and acceptable safeguards for the nuclear fuel reprocessing plants which are being planned, designed, and built throughout the world.

Construction of the BNFP had been encouraged by long-standing U. S. Government policy. In 1977 that policy was abruptly reversed due primarily to concern that plutonium from reprocessing plants elsewhere in the world might be diverted to nonpeaceful purposes. In implementation of this changed policy, the NRC terminated all licensing proceedings related to the reprocessing of spent nuclear fuel and recycle of recovered products, including the license applications for the Barnwell Plant.

Shortly thereafter, the Congress took action to preserve the BNFP as a major and unique asset of significant potential national and international importance. Since 1978, with Congressionally-authorized funding and under contract to the Department of Energy, the BNFP has been utilized effectively in research, development, and demonstration activities in direct support of national energy and nuclear nonproliferation objectives. In the latter area, Safeguards -- widely recognized as a keystone to further development of peaceful uses of nuclear energy -- has comprised a continually increasing portion of the Barnwell R&D program. This work has embraced the development of both physical protection and advanced nuclear material accountancy systems.

Specifically, the modern, full-scale BNFP has been uniquely capable of allowing development and preliminary testing of advanced safeguards technology. That technology, if employed in commercial reprocessing plants throughout the world, would significantly improve the ability to assure that special nuclear materials (a) will not be diverted and (b) that any significant losses will be detected almost immediately (through near-real-time accountability that provides hourly computerized measurements of plutonium inventories). The Barnwell-developed Safeguards System features the latest in computer technology, process monitors, intrusion detection devices, and access control systems. Many of the National Laboratories, capitalizing on advances they had previously made through work on defense programs, have been active participants in developing this new technology and in designing tests conducted at Barnwell.

The Safeguards System, thus cooperatively developed at Barnwell, appears capable of surpassing goals for diversion detection which were previously believed unachievable. Further demonstration of this System (as proposed by the Department of Energy for FY 1983) has been enthusiastically endorsed by the International Atomic Energy Agency.

Before proceeding further, I feel it important to emphasize that the BNFP is unique in all the world in having suitable facilities in which to conduct this complex development work which requires a modern, full-scale plant in which spent fuel has not been processed.

Current Safeguarding Procedures

Plutonium requires safeguarding -- both physical protection and material accountancy -- primarily because it might possibly be diverted to non-peaceful uses. There is by no means universal technical agreement that this fuel-grade plutonium could be successfully converted into a weapon. However, there is sufficient technical support for the view that a crude and inefficient weapon could be made from recovered fuel-grade plutonium to fully justify its safeguarding. But possibly of more practical importance, the intrinsic monetary value of plutonium as an energy source provides an additional excellent, and less arguable, reason for applying effective safeguards: plutonium is literally worth more than its weight in gold.

Current procedures of material accountancy for this valuable substance in reprocessing plants, both domestically and internationally, are based upon periodic (annual or semiannual) shutdowns and cleanouts of facilities. However, these procedures: (1) lack sufficient sensitivity to detect, in even moderately scaled facilities, the loss of meaningful quantities; (2) incur inherent delays which prevent timely detection of real or suspected diversions; and, (3) result in large financial penalties associated with loss of production during inventory shutdowns. The Safeguards System developed at Barnwell, with its increased sensitivity and near-real-time accountancy, addresses all three of these points. Consequently, the Barnwell Safeguards System fully justifies the International Atomic Energy Agency's strong support expressed in its August 4, 1981 statement*:

> "...we give a high priority to the further development and testing (of the BNFP system). If successfully completed as projected, the extended field test should provide highly valuable developmental data, much of which could not be obtained in any other way, and should contribute significantly to the IAEA's ability to define a generally acceptable and effective safeguards approach for large scale reprocessing facilities. (The IAEA) is prepared to cooperate fully in any way in planning, implementation, or evaluation of this integrated test."

Foreseen Problems in Gaining Acceptance

Increased sensitivity, timeliness of diversion detection, and avoidance of costly downtime for physical inventory purposes, all combine to provide a strong incentive for international acceptance of the Barnwell-developed Safeguards System. However, three problems remain to be resolved before this system is likely to be accepted as the international standard for incorporation in the reprocessing plants which are now being planned, designed, and built elsewhere in the world.

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*See Appendix B.

First, unhappy experience with earlier safeguarding procedures has led reprocessing plant operators to believe that safeguarding would result in substantial interference with efficient plant management. In recognition of this, the Barnwell Safeguards System has been developed from the outset by a technical staff with extensive practical operating experience in reprocessing plants. Consequently, the System -- as demonstrated by tests to date -- enhances rather than hinders plant operability and safety. In-line instruments, coupled with innovative video display control room techniques, improve plant operability. Moreover, the System should reduce materially production time lost for inventory purposes. Proof of such operational enhancement, through a sustained demonstration at the BNFP, would counteract the present generally held belief that safeguards are counterproductive to efficient plant operation.

Second, while tests of the System to date have been widely acclaimed, these tests have been conducted with only short (week-long) runs and in only a portion of the Plant. International acceptance will require demonstration of safeguards effectiveness and enhanced operability through sustained (two- to three-month) operation utilizing all components of the plant. Successful development activities over the past five years, at a cost to the Government of $30 million, have brought the Barnwell System to the state that it is now ready for such sustained demonstration, and this has been proposed by the DOE for FY 1983.

Third, it is important to note that there exists but a narrow time window in which to conduct the demonstration which is necessary to achieve international agreement on an acceptable, effective safeguards system. There are two reasons for this narrow window:

- The BNFP, as indicated earlier, is unique in being able to demonstrate such a system. However, its future is uncertain and decisions must be made fairly soon as to whether it is to be operated or shut down. If, in the national interest of energy conservation and effective waste management, the BNFP is scheduled to operate, then startup activities would, within a year or so, preclude safeguarding demonstrations. Conversely, if the BNFP is not to operate and the DOE-proposed demonstration is not funded, then the Plant would be shut down and its staff dispersed, eliminating any prospect for demonstration.

- Germany, Japan, the United Kingdom, and France are all proceeding with design of their commercial-scale reprocessing plants. Any delay in the DOE-proposed BNFP demonstration would risk that its results would come too late for most efficient inclusion in the design of these new plants.

Thus, only a short time remains for this unique opportunity to demonstrate and achieve international accord on an effective safeguards system.

Highlights of the BNFP-Developed System

The requested detailed description of safeguards programs at Barnwell has been included as an appendix. However, it appears appropriate to cite here a few highlights of the Safeguards System which has been developed and installed at Barnwell over the past five years. This System is comprised of separate, but integrated, material accountancy and physical protection components, each of which exemplifies the world's most advanced technology.

The Material Control and Accounting System includes more than 500 data points which provide process information for computerized assessment. This System is capable of performing a complete plant inventory once each hour. It has demonstrated a sensitivity previously believed unachievable, detecting diversions of as little as 100 grams per hour from this full-scale reprocessing plant.

The Physical Protection System includes installed access control components which positively identify an individual by voice print analysis and then track, monitor, and control his movement through 15 separate controlled areas of the Plant. Other physical protection components, including a variety of sophisticated detection devices, intrusion alarms, and display systems, have contributed to the Barnwell System's world-wide leadership in access control technology.

National Laboratories Input and Coordination

We would be extremely remiss if, in view of our references to the "Barnwell-developed" Safeguards Systems, we did not emphasize the important role played by the National Laboratories and other DOE-related institutions.

In practice, the BNFP has provided a full-scale, uncontaminated and expertly staffed nuclear fuel reprocessing plant with an installed Safeguards System that has been effectively used to develop data of urgent interest to National Laboratories. This has led to close cooperation with Los Alamos, Sandia, Oak Ridge, Brookhaven, and Lawrence Livermore National Laboratories, as well as the DOE-related Rocky Flats, Savannah River, and Hanford facilities.

This work has included provision of BNFP pulse column data to validate Los Alamos accountancy models; demonstration and improvement of a Los Alamos-developed diversion detection statistical method; testing of a Sandia-developed closed-loop control concept; testing of an Oak Ridge "Microscopic Process Monitoring" safeguards concept; demonstration of a Brookhaven vessel calibration system; installation of a BNFP-developed isotopic concentration monitor at Rocky Flats; implementation of advanced X-ray fluorescence analyzer monitoring developed at Lawrence Livermore; and transfer of color monitor display routines, as used in the BNFP, for use in the Savannah River Plant security system.

In addition to this close, direct cooperative relationship with National Laboratories, the BNFP staff has been called upon by these Laboratories to implement international programs in support of U. S. nuclear nonproliferation objectives. International training courses have been conducted by the BNFP staff under contract to Los Alamos, Sandia, and the International Safeguards Project Office of Brookhaven National Laboratory. Classes on Advanced Nuclear Materials Control and Accounting have been prepared and conducted by BNFP personnel in New Mexico in conjunction with Los Alamos National Laboratory. Under contract with Brookhaven, BNFP personnel have assisted the IAEA in establishing its overall training program for International Safeguards Inspectors and have conducted seminars for IAEA staff personnel on near-real-time accountancy and in-process inventory systems.

Appropriate Future Action

The BNFP and its staff have the capability to bring to fruition, in Fiscal Year 1983, all of the safeguards R&D work so successfully conducted there over the past five years. To achieve that goal, the DOE has proposed for FY 1983, a sustained demonstration run of the complete chemical separations portion of the BNFP, using natural uranium. This plant run would demonstrate the entire full-scale integrated Safeguards System, including its computerized material accountancy and physical protection systems, patrol officer interactions, and the collection, processing, and display of information in the plant's safeguards coordination center.

Japan, Germany, France, and the United Kingdom are all planning to build, in the near future, reprocessing plants similar to the BNFP. Demonstration of the effectiveness and value of the installed, state-of-the-art Barnwell Safeguards System, could materially influence the level of safeguards at these and other plants which will follow throughout the world. This would be in complete harmony with the Administration's nuclear nonproliferation policy statement of July 16, 1981 which calls for the United States to "strongly support and continue to work with other nations to strengthen the International Atomic Energy Agency, to provide for an improved international safeguards regime, and to re-establish this nation as a predictable and reliable partner for peaceful nuclear cooperation under adequate safeguards."

The Secretary of Energy, in a recent letter to Senator Thurmond (R-SC) stated that "Through example and stringent safeguards control, the United States can constructively influence the use of (plutonium) and the design of reprocessing plants in the rest of the world." The DOE-proposed FY 1983 Barnwell demonstration would provide a very effective "example" and thus the needed "influence". The BNFP is the only facility in the world that can make such impact, and 1983 presents a narrow, and probably once-only, time-window in which to achieve appropriate international agreement on effective safeguards. We believe that this opportunity should be taken now.

Conclusion

In summary, five years of close cooperation with the National Laboratories, the availability of the unique Barnwell Plant, and about $30 million of Congressionally-authorized funding have combined to develop the world's most advanced safeguards system.

Demonstration of this system on a sustained basis in Fiscal Year 1983, as proposed by the Department of Energy, provides the opportunity for the United States to exert leadership in achieving international agreement on effective and acceptable safeguards for nuclear fuel reprocessing plants throughout the world.

Thank you very much for your attention. We would be glad to entertain any questions on the Barnwell Nuclear Fuel Plant, its Safeguards Research and Development Program, or the future role of Barnwell in the area of safeguards.

APPENDIX A

DESCRIPTION OF BNFP SAFEGUARDS ACTIVITIES

Overview

The AGNS Technical Staff encompasses broad and varied backgrounds in nuclear fuel reprocessing and safeguards. The BNFP state-of-the-art safeguards expertise has been drawn from reprocessing plants throughout the world. This expertise, enhanced by the continuing close interaction with National Laboratories and funding for safeguards research from the Congress, has resulted in installation, in portions of the Barnwell Plant, of a Safeguards System which is widely recognized as the most modern, most sensitive, and most operable in the world. This Safeguards System integrates nuclear material control and accounting, physical protection and security, operations, and safety functions to provide unequaled defense in depth against theft or diversion of Special Nuclear Material or sabotage of the Plant.

The compatibility of this Safeguards System with plant operation has been verified by periodic operation of the BNFP using natural uranium to simulate nuclear fuel. During these runs, safeguards exercises were conducted that could not have been held at any other site in the world. In these exercises, ever-decreasing quantities of surrogate fuel were removed (diverted) from the process streams to measure the sensitivity of the System. Some diversion exercises were prearranged with the safeguards personnel; others were not. Discrete removals from monitored tanks of this 1500 metric ton per year plant were detected at diverted amounts as low as 100 grams. Protracted removals from flowing process streams were detected within 48 hours at removal rates as low as 100 grams/hour. These levels of detection had previously been widely considered unattainable, and that mistaken belief would still prevail if the DOE-sponsored development program had not resulted in installation of the present Safeguards System in the full-scale BNFP and the demonstration of its sensitivity.

The safeguards R&D efforts at BNFP have been separated into three areas to facilitate development. However, each area is fully integrated with the others to provide mutual benefits against the threats of diversion, theft, or sabotage. The three areas of development are Nuclear Materials Control and Accounting, Advanced Physical Protection, and Patrol Officer Effectiveness. In discussing each of these areas, it is important to emphasize that the results of these development efforts are "real" and not computer simulations. These results come from actual testing of safeguards concepts in an operational, full-sized, staffed reprocessing plant. Moveover, these systems are all transferable to other facilities.

Computerized Nuclear Material Control and Accounting

The Computerized Nuclear Material Control and Accounting System installed at the BNFP is a state-of-the-art, near-real-time accountancy and process-monitoring system. Development, which started as an AGNS-funded program in the mid-1970's, has consistently sought the following objectives:

1. To provide the very highest level of accuracy, sensitivity, and timeliness that is technically available.

2. To be operable and maintainable, using plant personnel; i.e., a system which does not require a cadre of outside specialists for its sustained operation.

3. To aid, rather than hinder, operation of the facility. (This objective has been not only achieved, but surpassed; operational benefits alone could justify the cost of installation of this System in new reprocessing plants.)

4. To be readily adaptable to other facilities in support of United States nonproliferation policy.

There are numerous functions within the Material Control and Accounting System that warrant mention. These include data acquisition where the on-line, real-time computer system is connected to over 500 instruments within the reprocessing facility from which it routinely and automatically gathers information. A second function is measurement whereby the computer controls the sequence, the timing, and the performance of instrument readings taking measurements and doing calculations as necessary on a four-minute cycle. Another function is measurement control. Redundant measurements are made both in terms of repeated measurements through time, and in terms of duplicate instrumentation. The measurement control program is used to establish automatically the levels of uncertainty and to assure that instrument drift or failure does not inject bad data into the calculations. A fourth function is item and seal control. This portion of the accountability system is employed in keeping track of discrete items such as product containers and fuel assemblies. The physical inventory function is used to aid the operators during the taking of physical inventories. The computer monitors the progress of taking the inventory and, in particular, is used to make sure that important conditions in the plant do not change prior to the completion of the entire inventory. Of course, the Material Control and Accounting System has accounting routines built into it; routines which rapidly and accurately compute material balances and inventory differences. The near-real-time inventory capability means that the system can automatically run a material balance around the entire plant, as well as around selected portions of the plant, as often as once an hour. Some process monitoring functions have been built into the system such as detecting flow in certain lines in directions opposite to appropriate flow, detecting if a liquid flow is present where there should only be gas, or detecting if there is radiation where there should not be radioactive material. Lastly, the function of process support provides the capability of taking information out of the accounting system, logging it and displaying it to the operating staff in such a way as to enhance safe and stable plant operation.

Laboratory Data System

A unique Computerized Laboratory Data System provides laboratory analysis data to the overall system. The Laboratory Data System, the development of which was initiated and funded by AGNS in 1973, focuses on a system of minicomputers in the laboratory area. It automatically reads data, does the calculations, and reports the results from analytical laboratory equipment, such as multi-channel analyzers, a mass spectrometer, balances, densimeters, and florophotometers. When the analyses are complete, the computer makes the results available to the BNFP material accounting computer and to long-term disk and magnetic tape storage. Laboratory data results are also available for rapid, near-real-time display in the control room and in the laboratory. The laboratory data system computer is both a stand-alone system and one which can communicate with other minicomputers in the BNFP safeguards computer network.

On line, process stream radiation monitors are used to provide real-time concentration data. In this area, the BNFP staff has significantly improved the state-of-the-art in both isotopic concentration monitors and X-ray fluorescent concentration monitors. AGNS is further developing these instruments for use at Rocky Flats and Lawrence Livermore, respectively.

Measurement Systems

Liquid level indications at Barnwell are obtained by dip-tube bubbler systems which have been a standard technique in the chemical industry and nuclear fuel reprocessing plants for years. To enhance their precision to satisfy safeguards objectives, the BNFP staff has developed new calibration and measurement routines. These routines use a combination of the dip-tube bubbler with precision quartz manometers to calibrate tankage within the Separations Plant, and can routinely reproduce readings to within a tenth of one percent. This represents a precision ten times better than has been previously used in the nuclear reprocessing field.

The BNFP staff has concurrently developed alternate equipment for liquid level indication using radio frequency probes. These probes and the supporting electronics represent a unique device for measuring liquid level in high acidity solutions. The precision of this system is equivalent to that obtained from the more expensive and more complicated quartz-bourdon tube manometers.

Diversion Test Results

At the BNFP the Computerized Nuclear Materials Control and Accounting System is a reality, is fully installed, and has been used to monitor the Plant's entire plutonium purification system. Over the past two years the BNFP staff has operated this system using natural uranium as surrogate fuel and has conducted diversion tests. As previously noted, diversions were conducted on both an abrupt and protracted basis. These exercises produced the following results: different abrupt diversions were conducted in which as little as 100 grams of material were removed from the process as rapidly as possible. The removals were made both from static storage tanks and from dynamic surge tanks. In 100% of those diversions, both announced and unannounced, the removal was detected using the Materials Control and Accounting Process-Monitoring systems.

Seven protracted diversions were conducted. In these seven tests, the removal rates of material from the process were between 200 and 600 grams per hour. The durations of the removal were from 12 to 16 hours, and again, in 100% of the tests, the diversions were detected. In a final test the diversion rate was reduced to 100 grams per hour which was at the sensitivity limit of the System, and detection was achieved. The statistical methods used to evaluate the data and to detect these low-removal rate diversions from the process equipment were developed by the Los Alamos National Laboratory.

The true threshold sensitivity of the system for detecting diversions has not yet been determined; thus, an investigation into this sensitivity is planned for 1983 along with evaluations of the System's sensitivity in the balance of the BNFP product streams.

Additional System Benefits

The Computerized Accounting System at the BNFP is continually proving itself useful, not only for accountancy and diversion detection purposes, but also as an aid to plant operation. Some of the benefits that have been demonstrated are:

(1) Shorter and less frequent physical inventories which allow more on-stream time.

(2) Improved accounting accuracy as a result of computer collection and treatment of the data. In addition, rapid comparisons of related data are made to ensure that the recorded data are correct.

(3) Rapid computer accumulation of accounting data provides not only near-real-time inventory results but a rapid collection, accounting, and control of the data for the periodic physical inventory.

(4) Improved product quality results from the rapid data collection, conversion, and display. The various out-of-limit routines and

other operational aids significantly help to keep the product quality high.

(5) Reduced paperwork results from the automatic computer collection and logging of data.

(6) Improved operating safety is seen as the computer screens and compares operational data for out-of-limit or dangerous conditions.

The BNFP staff has been working hard over the past five years to develop a nuclear materials control and accounting system that accomplishes national and international objectives and at the same time aids in the operation of the facility. Indications to date are that this system will not only meet national needs but enable the BNFP to approach International Atomic Energy Agency diversion detection goals far more closely than any other plant in the world.

Physical Protection and Access Control

The Physical Protection side of the BNFP safeguards development program has also progressed, pushing the state-of-the-art and leading the nation and the world in actual demonstration and operational testing. One of the major accomplishments of the Physical Protection work is the installation and testing of an Access Control System that is unique in its application to a nuclear fuel reprocessing plant. The Access Control System provides for positive personnel identification at the entry point to the controlled area, by verifying each individual's identity by voice print analysis. The individual's identity is then associated with a proximity card key so that as the person moves throughout the site he/she can be properly tracked, monitored, and authorized entry into controlled areas. Once the person leaves the controlled area and surrenders the proximity card, all association with the card is dissolved, and it is only re-established after voice verification is again performed.

While the individual's identity is being verified and then associated with a particular proximity card key at the entrance to the controlled area, the individual's authorization file is checked by the computer. This check is to verify that the individual has been administratively approved for entry into the controlled area; that the individual's shift assignment corresponds with the requested entry; and that the record of the individual's location does not indicate he/she is already inside the controlled area. As individuals present the proximity card keys to request access into the interior controlled areas, the computer identifies the individual by the card signal and again verifies that the individual has administrative approval for passage through that particular control point; that the individual is recorded in an adjacent control area; and that the area into which passage has been requested is not administratively restricted. As people move from one controlled area to another, a real time inventory of every area is maintained. This inventory may be queried at any time by safeguards or operational personnel to locate a particular person or to obtain a current listing of all personnel in a certain area. This feature opens many other applications of this data including: rapid personnel accounting after an emergency evacuation; rapid location of an individual based on a particular skill or attribute such as CPR training; and, dose calculations from the area radiation monitor readings multiplied by the length of time a person was in the area. The automated system also retains a historical record of each access request generated within the system. The computer files the time, date, individual's identity, the description of the access requested, and the action taken by the system. In the event of an access denial decision, the basis for this denial is recorded. All past records can be searched by the computer to reconstruct a series of events or a person's movement within any time frame. At the BNFP, the existing Access Control System currently covers 15 different controlled areas, has been controlling and monitoring 24 hour/day, 7 day/week for over a year, and has recorded nearly one million access events. This access control concept has been thoroughly demonstrated at the BNFP.

Other work has been done in the areas of using canines to detect explosives, the computerization and simplification of the display of plant intrusion alarms, the use of intrusion detection systems in unusual physical configurations such as around sharp corners, up steep hills, and over pipeways, and the training of special tactical patrol force teams to counter immediate threats prior to availability of off-site assistance. All of these physical protection investigations have provided valuable operational data for future nuclear facilities.

INTERNATIONAL ATOMIC ENERGY AGENCY
AGENCE INTERNATIONALE DE L'ENERGIE ATOMIQUE
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IN REPLY PLEASE REFER TO:
PRIERE DE RAPPELER LA REFERENCE: —

1981-08-04

Sir,

I have the honour to refer to the nuclear energy policy statement of U.S. President Reagan on 16 July 1981, as well as to the various cooperative efforts between the United States of America (and other Member States) and the IAEA related to a safeguards concept commonly referred to as near-real-time materials accountancy. This concept, one of several which have been suggested for use in safeguards at large scale reprocessing plants, is showing increasing promise, and we accordingly give a high priority to its further development and testing.

In this connection we understand that the Allied Gulf Nuclear Services Co., owners of the reprocessing facility at Barnwell So. Car., are seeking international cooperation and sponsorship for an extended integrated demonstration of the near-real-time materials accountancy system which has been under development in recent years at the AGNS-Barnwell facility. Specifically, we understand that they contemplate operating the Barnwell facility for a period of about four months using unirradiated natural uranium feed, during which time they hope to demonstrate:

- the feasibility of real-time in-process physical inventories on a routine basis without adversely affecting process operations;
- the ability of the n.r.t. accountancy and associated containment-surveillance measures they have developed to detect simulated abrupt and protracted diversions;
- the reliability and cost effectiveness of the installed safeguards equipment.

I would like to express my strong support for this project. If successfully completed as projected, the extended field test should provide highly valuable developmental data, much of which could not be obtained in any other way, and should contribute significantly to the IAEA's ability to define a generally acceptable and effective safeguards approach for large scale reprocessing facilities.

.../2

The Resident Representative of the
United States of America to the
International Atomic Energy Agency
Kundmanngasse 21-25
1030 Vienna

The Department of Safeguards is prepared to cooperate with the U.S. Government and with the AGNS-Barnwell organization in any way they can in planning, implementation, or evaluation of the results of this integrated test.

Accept, Sir, the assurances of my highest consideration.

H. Gruemm
Deputy Director General
Department of Safeguards

for DIRECTOR GENERAL

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Mrs. BOUQUARD. Thank you very much.

Dr. Nilson, would you proceed with your testimony?

STATEMENT OF DR. ROY NILSON, MANAGER OF CORPORATE LICENSING, EXXON NUCLEAR CO.

Dr. NILSON. Madam Chairman and members of the subcommittee, I am pleased to have this opportunity to testify before you on this very important subject related to nuclear safeguards. I will excerpt from my written testimony and I ask that my complete testimony including a recent paper presented to the Institute of Nuclear Materials Management be included in the record.

Mrs. BOUQUARD. Without objection, it will be made a part of the record. You may summarize or proceed as you wish.

Dr. NILSON. Thank you, Madam Chairman.

My name is Roy Nilson and I am manager of corporate licensing for Exxon Nuclear Co. In that role I am responsible for the licensing and nuclear regulatory aspects which include, as an important part of them, safeguards. My remarks will be limited to our own experience, which is in the front end of the fuel cycle, namely in the safeguarding of low-enriched uranium. Since our Richland facility was chosen by the IAEA in early 1981 as the first bulk-handling facility to come under IAEA safeguards in the United States, I will discuss our experience from both a national and international standpoint.

Exxon Nuclear employees have participated in safeguards programs for many years, both here and abroad. My paper summarizes some of these activities and I will just mention a few here to give you an idea of our background.

We have participated in much of the IAEA's work in developing quantitative verification methods for safeguards. Our company has also provided consulting services to the IAEA in the areas of inspection strategy, effectiveness evaluation, and safeguards principles. We have been codirectors in two U.S.-sponsored courses in 1979 and 1981 for the IAEA member-State students on State systems of accounting and control. Our Richland fuel fabrication plant was used as the model plant for these courses to illustrate an operating safeguards system for meeting both State or National and IAEA requirements.

Also, joint efforts have been carried out with the Sandia & Ispra Laboratories in the development of seals for fuel assemblies. Such seals, applied in a fuel fabrication plant, will remain with the fuel throughout its lifetime, thus preserving the integrity of the initial verifications made during fuel fabrication.

These laboratories recognized early in their research and development efforts the importance of bringing in industrial partners so that the final product is practical, acceptable, and workable. This effort has now progressed to the point where a seal has been developed for boiling water reactor fuel and is currently undergoing preliminary tests. The seal can be remotely interrogated ultrasonically to uniquely identify a fuel assembly and also give any evidence of tampering. In-reactor testing will be carried out in the Kahl reactor in West Germany which is fueled by both German vendor fuel and Exxon Nuclear fuel, thus providing a unique and ideal vehicle for a cooperative United States-European program. The progress toward a similar seal for pressurized water reactor fuel assemblies is not as far along.

We base our accountability measurements during fuel manufacturing on weight and destructive analyses for percent uranium and enrichment but, additionally, we use several nondestructive assay instruments in conjunction with our quality control and safeguards measurements. These instruments, now in routine use, have been developed under the U.S. safeguards R&D program and the industry is already making use of these systems for their own accountability and quality control systems.

My paper summarizes some of these instruments, which have been discussed previously by other testifiers. I will also later summarize their use by the inspectors, which I think is very important because the inspectors have been able to use the same instrumentation that the operators use for safeguards verification.

I will be concentrating mainly on our experience under IAEA safeguards. After 18 months and seven inspections in our Richland facility, considerable firsthand experience has been obtained in the actual implementation of IAEA safeguards in a U.S. bulk handling facility. Two important conclusions can be made at this time: First, IAEA safeguards in a low-enriched fuel fabrication plant need not be overly burdensome to the plant operator. Second, inventory verification by agency verification by agency inspectors can be made to a high degree of exactness using largely state-of-the-art measurements.

Verification of our inventory is made by the inspectors using an attribute-variables sampling plan. This type of random sampling can detect with high probability the absence of a quantity of nuclear material of safeguards importance from the plant's inventory. The inspector's goal is to detect with a 95 percent probability that less than 75 kilograms of U-235 contained in our fuel has not been missed.

Several examples exist in which nondestructive assay instruments have been useful in this verification. As I said before, these instruments have been developed under safeguards research and development programs and some have been in routine use for some time in plants of our type.

The first example is a stabilized assay meter, the so-called SAM-2 enrichment meter, which has been developed and is now provided by the commercial vendor industry for verification of uranium samples. For uranium oxide powder the inspectors use our SAM-2 enrichment meter for their attribute tests. The selected buckets of powder are first weighed and then machine tumbled to mix the powder prior to the measurement. The tumbling insures that any substituted inert materials would be detected. After the SAM-2 measurements have been completed, a fraction of the buckets is sampled for uranium and U-235 later at the IAEA laboratory in Vienna. These samples provide the inspectors with the necessary independent standards for their use of our instrumentation.

The second example is the active fuel rod scanner, which has also been developed in the United States and is now commercially available. Fuel rods are randomly selected by the inspectors for verification and are measured for total fissile content with the scanner. The rods are then compared against full-length rods selected from reject or excess inventories which match the rods tested. A few of these standard rods are downloaded in the presence of the inspectors and their fuel pellets are removed for weight verification and later destructive analysis. Again, this provides the inspectors with an independent check on the use of our equipment.

A third example is an intrinsic germanium detector which is used to measure the enrichment of UF-6 in cylinders. This instrument is the property of the Agency and is left at our plant while they are not there.

Now in addition to these above devices, the inspectors have tested three new instruments which have been recently developed. One of these is a load cell which enables the inspectors to independently weigh our UF-6 cylinders in situ rather than moving them to our central scale. The load cell should also prove useful to us, as it permits the cylinder to be weighed in situ rather than having to move it to a central scale, which saves time.

Most recently, the Los Alamos Laboratory developed neutron coincidence collar was used by the inspectors to verify the content of some of our fuel. The initial application went very well, with agreement with our enrichment data within a few percent. The development of this device has also been coordinated by Los Alamos scientists with fuel fabrication plant operators in the United States and Europe.

Our close interaction with the agency's inspectors has provided the IAEA with several opportunities to improve the efficiency of their inspection. Several of the techniques that I have just described were innovations which were jointly evolved during the course of the inspections.

In addition, several procedural innovations and scheduling arrangements were jointly developed which have also made the inspections more efficient. One must recognize that it is not necessary that the inspector do a 100 percent verification of the inventory. A 100 percent item count is not practicable. The total number of items can be verified randomly, but this can be done validly only if the inspector is first provided with a list of the total inventory of items so he can select his samples.

It is also necessary that the inspector be assured that the operator's final listing of his inventory after a final reconciliation is the same as that provided earlier, prior to verification. After the agency's inspection, the operator knows which items the inspectors have verified. If later, in the final listing sent to the inspector, the operator alters the values of the items not verified by the inspector, of course the verification is meaningless.

Therefore, by providing the inspector with both a provisional list just after our inventory taking and prior to his verification, and later a final inventory listing after we have reconciled our books, the inspector can then make a one-to-one comparison between the two lists and assure that the final inventory listing is consistent with the initial list and that the inventory item values sum to the correct totals.

We had early concern over the potential for lost production time while inspectors complete their verification. This has not proven to be the case. In addition to the two-list approach already discussed, our inventory taking was scheduled near a normal production break so that the inspectors could verify during a normal period shutdown. With this scheduling, the inventory by the IAEA has so far been able to be completed with only a few hours of lost production.

The main burden we have experienced to date is our manpower costs for escorting inspectors, locating items for verification measurements, performing measurements for them under their witness, preparing accounting reports, inventory lists, and other incidental services. Over the 18 months to date, this manpower cost equates to less than one tenth of 1 percent of the fuel fabrication costs.

These technical and procedural innovations previously discussed have been instrumental in increasing the effectiveness and reducing the cost of the verification effort, and they have been due in large measure to innovative applications of NDA instrumentation. For example, the use of our rod scanner saves the inspectors 4 man-days of time per inventory verification compared with a manual scan of fuel rods with a different type of instrument. The use of our SAM-2 enrichment meter for the attribute tests for powder has reduced the variables sample size by a factor of three. The load cell for weighing UF-6 cylinders will reduce considerably the time to verify UF-6 weights. Finally, the neutron collar for fuel assemblies enables for the first time the verification of final product.

However, there are still some future needs and problems. As evidenced from the discussion to this point, measurement and verification of uranium inventories in a low-enriched uranium fuel fabrication plant are largely possible with destructive and nondestructive methods available today. The results of the R&D programs are being effectively utilized. The remaining deficiency lies in the verification of finished fuel assemblies and the neutron coincidence collar developed by Los Alamos appears to be a powerful tool in closing this gap. A remaining step is to integrate this instrument into the appropriate point or points in the fuel cycle. This becomes an application R&D task. To be most effective, this task should be worked jointly with the industry and the Agency.

Similarly, the fuel assembly seal mentioned earlier under joint development by Sandia & Ispra will be another important device in closing this gap. Here industry cooperation has been solicited and used and the boiling water reactor seal is entering its final application R&D phase. Close liaison and cooperation with the industry, including the reactor operators on whose fuel these devices must be attached, are of great importance.

In conjunction with efforts to develop practical solutions to the verification of the flow of finished fuel elements from fuel fabricators, there is a possibility of verification by the reactor itself, and this may be worth exploration. In cases where there is international independence between the fuel fabricator and the power reactor operator, the reactivity tests which are normally carried out upon reactor startup after fuel loading should provide a useful verification of fresh fuel content. That is, the tests could detect the absence of a quantity of safeguards importance.

Also, IAEA inspection of U.S. facilities provide a practical training ground for the inspectors and can also serve to demonstrate to other countries how practical, cost effective international safeguards can be carried out. It may be worthwhile to consider supporting such demonstration projects at U.S. plants under IAEA safeguards.

In conclusion, our assessment of the IAEA's verification in our Exxon Nuclear facility in Richland is that the inventory in a light water reactor fuel fabrication plant can be verified by independent measurements at a modest burden to the operator. With respect to the scope and adequacy of the research and development programs to date, I believe the point has been reached where instruments, not already in use, can now be applied. The remaining task lies in the transition of the laboratory devices into actual, practical use. Broader industrial participation will be essential in this transitional phase, and such participation should assist in getting safeguards equipment and techniques into routine use both domestically and by the Agency. In fact, as has already been demonstrated, some of the new instruments, such as the load cell, can also be an advantage to the operator.

Finally, the operator-inspector interface is of extreme importance. Our experience has shown that a nonadversarial approach with mutual cooperation has best enabled the realization of both our objective of minimum intrusion and burden and the agency's objective of effective safeguards. The satisfactory demonstration of these two objectives should also aid in getting advanced safeguards systems in use. If the operator is made to feel that his concerns are recognized, the task of implementing effective safeguards is vastly easier.

Thank you. I will be glad to answer any questions you may have.

[The prepared statement of Dr. Nilson follows:]

STATEMENT OF ROY NILSON, MANAGER
CORPORATE LICENSING, EXXON NUCLEAR COMPANY
BEFORE
SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY

AUGUST 4, 1982

MADAM CHAIRMAN BOUQUARD AND MEMBERS OF THE COMMITTEE: I AM PLEASED TO HAVE THIS OPPORTUNITY TO TESTIFY BEFORE YOU ON THIS IMPORTANT SUBJECT RELATED TO NUCLEAR SAFEGUARDS.

EXXON NUCLEAR IS A WHOLLY-OWNED SUBSIDIARY OF EXXON CORPORATION. THE COMPANY HAS, SINCE 1971, OPERATED A FUEL FABRICATION PLANT IN RICHLAND, WASHINGTON. FUEL FABRICATION AND RELATED SERVICES EXIST FOR BOTH PRESSURIZED AND BOILING WATER REACTORS. EXXON NUCLEAR THROUGH ITS SUBSIDIARY EXXON NUCLEAR GMBH ALSO OPERATES A FUEL ASSEMBLY PLANT IN LINGEN, WEST GERMANY.

MY ACADEMIC BACKGROUND IS A DOCTOR OF PHILOSOPHY DEGREE IN NUCLEAR PHYSICS FROM THE UNIVERSITY OF ILLINOIS IN 1956. MY ENTIRE PROFESSIONAL CAREER HAS BEEN IN NUCLEAR ENERGY PROGRAMS FOR BOTH GOVERNMENT CONTRACTORS AND PRIVATE INDUSTRY. I JOINED EXXON NUCLEAR AT ITS INCEPTION IN 1969 AND HAVE BEEN RESPONSIBLE FOR ITS LICENSING AND NUCLEAR REGULATORY AFFAIRS SINCE THAT TIME. NUCLEAR SAFEGUARDS HAS BEEN AN IMPORTANT SEGMENT OF THIS RESPONSIBILITY.

MY REMARKS WILL BE LIMITED TO OUR OWN EXPERIENCE, WHICH IS IN THE FRONT END OF THE FUEL CYCLE, NAMELY IN THE SAFEGUARDING OF LOW ENRICHED URANIUM. SINCE, OUR RICHLAND FACILITY WAS CHOSEN BY THE INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA OR AGENCY) IN EARLY 1981 AS THE FIRST U.S. BULK-HANDLING FACILITY TO COME UNDER IAEA SAFEGUARDS, I WILL DISCUSS OUR EXPERIENCE WHICH MAY BE USEFUL FROM THE STANDPOINT OF BOTH THE DOMESTIC AND INTERNATIONAL ASPECTS OF SAFEGUARDS. A PAPER PRESENTED TO THE INSTITUTE OF NUCLEAR MATERIALS MANAGEMENT CONFERENCE LAST MONTH IN WASHINGTON, D.C. PROVIDES THE LATEST INFORMATION RELATED TO OUR EXPERIENCE UNDER IAEA SAFEGUARDS, AND IT IS ATTACHED AS WRITTEN TESTIMONY.

BACKGROUND

EXXON NUCLEAR EMPLOYEES HAVE PARTICIPATED IN SAFEGUARDS PROGRAMS FOR MANY YEARS, BOTH HERE AND ABROAD. A BRIEF SUMMARY OF THESE PROGRAMS MAY BE OF INTEREST IN ESTABLISHING A REFERENCE FOR LATER DISCUSSION.

FOR A NUMBER OF YEARS, WE HAVE PROVIDED CONSULTING SERVICES TO THE IAEA VIA A U.S. GOVERNMENT CONTRACT. AN EXXON NUCLEAR STATISTICIAN WAS THE MAIN AUTHOR OF THE STATISTICAL PART OF THE IAEA SAFEGUARDS TECHNICAL MANUAL. WE PARTICIPATED IN THE DEVELOPMENT OF THE BASIS FOR THE QUANTITATIVE VERIFICATION OF MATERIAL QUANTITIES. OUR COMPANY HAS ALSO PROVIDED CONSULTING SERVICES TO THE IAEA IN THE AREAS OF INSPECTION STRATEGY, EFFECTIVENESS EVALUATION, AND SAFEGUARDS PRINCIPLES.

OUR STATISTICIAN ALSO CONTRIBUTED TO DEVELOPMENT OF DOMESTIC AND INTERNATIONAL SAFEGUARDS BY WRITING A BOOK ON "STATISTICAL METHODS IN NUCLEAR MATERIAL CONTROL". THAT BOOK, WHICH WAS PUBLISHED UNDER THE SPONSORSHIP OF THE ATOMIC ENERGY COMMISSION, HAS SERVED AS THE BASIC SAFEGUARDS STATISTICS TEXT SINCE 1973.

WE HAVE BEEN CO-DIRECTORS OF TWO U.S.-SPONSORED COURSES (1979 AND 1981) FOR THE IAEA MEMBER STATE STUDENTS ON STATE SYSTEMS OF ACCOUNTING AND CONTROL. OUR RICHLAND FUEL FABRICATION PLANT WAS USED AS THE MODEL PLANT FOR THESE COURSES TO ILLUSTRATE AN OPERATING SAFEGUARDS SYSTEM FOR MEETING BOTH STATE (NATIONAL) SYSTEMS AND IAEA REQUIREMENTS.

JOINT EFFORTS HAVE BEEN CARRIED OUR WITH THE SANDIA AND ISPRA LABORATORIES IN THE DEVELOPMENT OF SEALS FOR FUEL ASSEMBLIES. SUCH SEALS, APPIED IN A FUEL FABRICATION PLANT, WILL REMAIN WITH THE FUEL THROUGHOUT ITS LIFETIME, THUS PRESERVING THE INTEGRITY OF THE INITIAL VERIFICATIONS MADE DURING FUEL FABRICATION.

THESE LABORATORIES RECOGNIZED EARLY IN THEIR RESEARCH AND DEVELOPMENT EFFORTS THE IMPORTANCE OF BRINGING IN INDUSTRIAL PARTNERS SO THAT THE FINAL PRODUCT IS PRACTICAL, ACCEPTABLE AND WORKABLE. THIS EFFORT HAS NOW PROGRESSED TO THE POINT WHERE A SEAL HAS BEEN DEVELOPED FOR BWR FUEL AND IS CURRENTLY UNDERGOING PRELIMINARY TESTS. THE SEAL CAN BE REMOTELY

INTERROGATED ULTRASONICALLY TO UNIQUELY IDENTIFY A FUEL ASSEMBLY AND ALSO GIVE ANY EVIDENCE OF TAMPERING. THE TESTING IS BEING CARRIED OUT IN THE KAHL REACTOR IN WEST GERMANY WHICH IS FUELED BY BOTH GERMAN VENDOR FUEL AND EXXON NUCLEAR FUEL, THUS PROVIDING A UNIQUE AND IDEAL VEHICLE FOR A COOPERATIVE U.S.-EUROPEAN PROGRAM. THE PROGRESS TOWARDS A SIMILAR SEAL FOR PWR FUEL ASSEMBLIES IS NOT AS FAR ALONG.

OUR BASIC ACCOUNTABILITY MEASUREMENTS DURING FUEL MANUFACTURING ARE BASED ON WEIGHT AND DESTRUCTIVE ANALYSES FOR PERCENT URANIUM AND ENRICHMENT. ADDITIONALLY, WE USE SEVERAL NON-DESTRUCTIVE ASSAY INSTRUMENTS IN CONJUNCTION WITH OUR QUALITY CONTROL AND SAFEGUARDS MEASUREMENTS. THESE INSTRUMENTS HAVE BEEN DEVELOPED UNDER THE U.S. SAFEGUARDS R&D PROGRAM.

WE USE A PASSIVE GAMMA COUNTER (SODIUM IODIDE DETECTOR) TO MEASURE THE U-235 CONTENT OF OUR SOLID WASTE CONTAINERS. WE USE BOTH PASSIVE AND ACTIVE FUEL ROD SCANNERS FOR ENRICHMENT CONTROL AND FOR SAFEGUARDS VERIFICATION. THE ACTIVE SCANNER COUNTS THE DELAYED NEUTRONS AND GAMMA RAYS PRODUCED BY NEUTRON INDUCED FISSIONS IN THE URANIUM FUEL PELLETS. A CF-252 SOURCE PROVIDES THE NEUTRONS.

THE ACTIVE ROD SCANNER CAN DETECT THE PRESENCE OF A SINGLE PELLET WHICH DIFFERS FROM THE AVERAGE ENRICHMENT BY ABOUT 20 PERCENT RELATIVE. THE PRECISION OF THE INSTRUMENT FOR MEASURING THE TOTAL FISSILE CONTENT OF THE FUEL ROD IS ABOUT 0.6 PERCENT AT ONE STANDARD DEVIATION.

WE ALSO MAKE EXTENSIVE USE OF THE STABILIZED ASSAY METER (SAM-2) FOR ENRICHMENT CONTROL AND FOR THE ACCOUNTABILITY MEASUREMENTS OF SMALL QUANTITIES OF SCRAP MATERIALS. THIS INSTRUMENT HAS A PRECISION OF ABOUT 1-2 PERCENT RELATIVE AT ONE STANDARD DEVIATION FOR MOST OF OUR APPLICATIONS.

EXPERIENCE UNDER IAEA SAFEGUARDS

After 18 months and seven IAEA inspections in our Richland facility, considerable first-hand experience has been obtained in the implementation of IAEA safeguards in a U.S. bulk-handling facility. Two important conclusions can be made at this time. First, IAEA safeguards in a low-enriched fuel fabrication plant are not overly burdensome to the plant operator. Second, inventory verification by Agency inspectors can be made to a high degree of exactness using largely state-of-the-art measurements.

The seven inspections, occurring on the average of once every two months, have included two inventory verifications, each requiring four to six days and five shorter inspections involving nondestructive measurements, observation of our measurements, selection of random samples and record and report audits.

Verification of our uranium inventory statement is made by the inspectors using an attribute-variables sampling plan. This type of random sampling can detect with high probability the absence (or overstatement) of a quantity of nuclear material of safeguards importance from the plant's inventory. The inspector's attribute sample sizes for the inventory verifications are based on a goal quantity of 75 kg of U-235 contained and a sampling probability of 0.95% of including at least one gross defect in the sample.

Several examples exist in which Non-Destructive Assay (NDA) instruments have proven useful in the Agency's verification. These instruments have been developed under safeguards research and development programs; some have been in routine use for some time for both quality control and safeguards measurements in fuel fabrication plants.

The first example is the SAM-2 enrichment meter. For UO_2 powder verification, the inspectors use our SAM-2 enrichment meter for their attribute test. The selected powder buckets are first weighed and then machine tumbled to mix the UO_2 prior to the measurement. The tumbling insures that any substituted inert materials would be detected. After the SAM-2 measurements have been completed, a fraction of the buckets is

SAMPLED FOR U AND U-235 ANALYSES LATER AT THE IAEA LABORATORY. THESE SAMPLES PROVIDE THE INSPECTORS WITH THE NECESSARY INDEPENDENT STANDARDS FOR USE OF OUR SAM-2 THEY ALSO PROVIDE THE DATA FOR THE INSPECTORS' VARIABLES TEST. INDEPENDENCE OF THE ATTRIBUTE TEST IS PRESERVED BY COMPLETING THE UO_2 ENRICHMENT MEASUREMENTS ON ALL OF THE BUCKETS USED IN THE ATTRIBUTE TEST BEFORE ANY BUCKETS ARE SELECTED BY THE INSPECTORS FOR SAMPLING.

THE SECOND EXAMPLE IS THE ACTIVE FUEL ROD SCANNER. FUEL RODS ARE RANDOMLY SELECTED BY THE INSPECTORS FOR VERIFICATION AND ARE MEASURED FOR TOTAL FISSILE CONTENT WITH THE SCANNER. THE RODS ARE COMPARED AGAINST FULL LENGTH RODS SELECTED FROM REJECT OR EXCESS FUEL ROD INVENTORIES MATCHING THE RODS TESTED. A FEW OF THE "STANDARD" RODS ARE DOWNLOADED IN THE PRESENCE OF THE INSPECTORS AND THEIR FUEL PELLETS ARE REMOVED FOR WEIGHT VERIFICATION AND LATER DESTRUCTIVE ANALYSIS AT IAEA HEADQUARTERS.

THE THIRD EXAMPLE IS AN INTRINSIC GERMANIUM DETECTOR AND MULTI-CHANNEL ANALYZER WHICH IS USED TO MEASURE THE ENRICHMENT OF UF_6 IN CYLINDERS. AN ULTRASONIC THICKNESS GAUGE IS ALSO USED TO MEASURE THE THICKNESS OF THE CYLINDER WALL TO CORRECT FOR THE ABSORPTION OF THE U-235 GAMMA RAYS BY THE STEEL CYLINDER WALL. THIS INSTRUMENT IS THE PROPERTY OF THE AGENCY.

IN ADDITION TO THE ABOVE DEVICES, THE INSPECTORS HAVE TESTED THREE NEW INSTRUMENTS OR DEVICES AT OUR RICHLAND PLANT. A DEVICE RECENTLY INTRODUCED FOR UF_6 WEIGHT VERIFICATION IS A LOAD-CELL. THE DEVICE, WHICH FITS OUR UF_6 CYLINDER CRANE, IS USED BY THE INSPECTORS TO INDEPENDENTLY VERIFY THE GROSS WEIGHT OF THE CYLINDERS. THE INITIAL USE OF THIS DEVICE WENT VERY WELL OPERATIONALLY, AND AGREEMENT WITH OUR SCALE WAS WITHIN MEASUREMENT UNCERTAINTY. THE LOAD CELL SHOULD ALSO PROVE USEFUL TO FUEL FABRICATORS, AS IT PERMITS UF_6 CYLINDER WEIGHING IN SITU, RATHER THAN HAVING TO MOVE THEM TO A CENTRAL SCALE.

MOST RECENTLY, THE LOS ALAMOS DEVELOPED NEUTRON COINCIDENCE COLLAR WAS USED BY THE IAEA INSPECTORS TO VERIFY THE CONTENT OF SOME OF OUR FUEL ASSEMBLIES. THE INITIAL APPLICATION WENT VERY WELL OPERATIONALLY, WITH

AGREEMENT WITH OUR FUEL ASSEMBLY ENRICHMENT WITHIN A FEW PERCENT. THE DEVELOPMENT OF THIS DEVICE HAS ALSO BEEN COORDINATED BY LOS ALAMOS SCIENTISTS WITH FUEL FABRICATION PLANT OPERATORS IN THE U.S. AND EUROPE.

THE THIRD DEVICE IS A PLASTIC SHRINK TUBE FOR SEALING THE VALVES ON UF_6 CYLINDERS. THE SEAL CONSISTS OF TWO PLASTIC TUBES. THE FIRST TUBE, WHICH HAS A PATTERNED AREA, IS SHRUNK AROUND THE VALVE WITH A HEAT GUN, THEN A SECOND PLASTIC TUBE WITH A DIFFERENT PATTERN IS SHRUNK OVER THE FIRST PATTERN, THUS FORMING A UNIQUE PATTERN WHICH CAN BE PHOTOGRAPHED OR SKETCHED. THE TUBE SEAL WAS SUCCESSFULLY USED BY THE INSPECTORS TO SEAL THE VALVE OF A CYLINDER WHICH HAD BEEN PREVIOUSLY VERIFIED BY NDA AND LATER SCHEDULED FOR SAMPLING DURING PROCESSING.

CLOSE INTERACTION WITH THE AGENCY'S INSPECTORS HAS PROVIDED THE IAEA WITH SEVERAL OPPORTUNITIES TO IMPROVE THE EFFICIENCY OF THEIR INSPECTION. SEVERAL OF THE TECHNIQUES AND INSTRUMENT APPLICATIONS JUST DESCRIBED WERE INNOVATIONS JOINTLY EVOLVED DURING THE COURSE OF THE INSPECTIONS.

IN ADDITION, PROCEDURAL INNOVATIONS AND SCHEDULING ARRANGEMENTS WERE JOINTLY DEVELOPED WHICH HAVE ALSO MADE THE INSPECTIONS MORE EFFICIENT. ONE MUST RECOGNIZE THAT IT IS NECESSARY THAT THE INSPECTOR BE ABLE TO VERIFY THAT ALL OF THE INVENTORY ITEMS CLAIMED BY THE OPERATOR ARE ACTUALLY PRESENT. A 100% ITEM COUNT IS NOT PRACTICABLE, NOR NEEDED; THE TOTAL NUMBER OF ITEMS CAN BE VERIFIED RANDOMLY. BUT, THIS CAN ONLY BE DONE VALIDLY IF THE INSPECTOR IS FIRST PROVIDED A LIST OF THE INDIVIDUAL INVENTORY ITEMS FOR SELECTING HIS SAMPLES. IT IS ALSO NECESSARY THAT THE INSPECTOR BE ASSURED THAT THE OPERATOR'S FINAL INVENTORY LISTING (AFTER RECONCILIATION) IS THE SAME AS THAT PROVIDED EARLIER PRIOR TO VERIFICATION. AFTER THE AGENCY'S INSPECTION, THE OPERATOR KNOWS WHICH ITEMS THE INSPECTORS HAVE VERIFIED. IF LATER, IN THE FINAL LISTING SENT TO THE INSPECTOR, THE OPERATOR ALTERS THE VALUES OF THE ITEMS NOT VERIFIED BY THE INSPECTOR, THE VERIFICATION BECOMES MEANINGLESS.

BY PROVIDING THE INSPECTOR BOTH A PROVISIONAL INVENTORY LIST JUST AFTER OUR INVENTORY TAKING AND PRIOR TO HIS VERIFICATION AND LATER A FINAL INVENTORY LISTING AFTER OUR RECONCILIATION, THE INSPECTOR CAN MAKE A ONE-TO-ONE COMPARISON BETWEEN THE TWO LISTS AND ASSURE THAT THE FINAL INVENTORY LISTING IS CONSISTENT WITH THE INITIAL LIST AND THAT THE INVENTORY ITEM VALUES SUM TO THE CORRECT TOTALS.

EARLY CONCERN OVER THE POTENTIAL FOR LOST PRODUCTION TIME WHILE THE INSPECTORS COMPLETED THEIR VERIFICATION OR HAVING TO SLOW OR HALT PRODUCTION IN CERTAIN AREAS SO THAT IAEA VERIFICATION MEASUREMENTS CAN BE MADE HAS NOT MATERIALIZED. IN ADDITION TO THE "TWO-LIST" APPROACH ALREADY DISCUSSED, OUR INVENTORY TAKING WAS SCHEDULED NEAR A NORMAL PRODUCTION BREAK SO THAT THE INSPECTORS' VERIFICATION COULD BE CARRIED OUT DURING A NORMAL PLANT SHUTDOWN PERIOD. WITH THIS SCHEDULING, THE IAEA INVENTORY VERIFICATIONS HAVE SO FAR BEEN ABLE TO BE COMPLETED WITH ONLY A FEW HOURS OF LOST PRODUCTION.

THE MAIN BURDEN EXPERIENCED TO DATE IS OUR MANPOWER COSTS FOR ESCORTING INSPECTORS, LOCATING ITEMS FOR VERIFICATION MEASUREMENTS, PERFORMING VERIFICATION MEASUREMENTS, PREPARING ACCOUNTING REPORTS AND INVENTORY LISTS, AND PROVIDING INCIDENTAL SERVICES. OVER THE EIGHTEEN MONTHS TO DATE, THIS MANPOWER COST EQUATES TO LESS THAN 0.1% OF THE FUEL FABRICATION COSTS.

THE TECHNICAL AND PROCEDURAL INNOVATIONS PREVIOUSLY DISCUSSED HAVE BEEN INSTRUMENTAL IN INCREASING THE EFFECTIVENESS AND REDUCING THE COST OF THE VERIFICATION EFFORT. THEY HAVE BEEN DUE IN LARGE MEASURE TO INNOVATIVE APPLICATIONS OF NDA INSTRUMENTS. THE USE OF OUR ROD SCANNER SAVES APPROXIMATELY FOUR MAN-DAYS OF INSPECTOR-OPERATOR TIME PER INVENTORY VERIFICATION COMPARED WITH A MANUAL SCAN OF FUEL RODS WITH A PASSIVE GAMMA COUNTER. THE USE OF THE SAM-2 ENRICHMENT METER FOR THE ATTRIBUTE TEST HAS REDUCED THE VARIABLES SAMPLE SIZE BY A FACTOR OF THREE FROM WHAT IT WOULD HAVE BEEN IF THE VARIABLES METHOD (WEIGHING, SAMPLING, AND ANALYSIS) HAD BEEN USED IN TOTAL. THE LOAD CELL FOR WEIGHING UF_6 CYLINDERS WILL REDUCE CONSIDERABLY THE TIME TO VERIFY UF_6 WEIGHTS. THE NEUTRON COLLAR FOR FUEL ASSEMBLIES ENABLES FOR THE FIRST TIME THE VERIFICATION OF FINAL PRODUCT.

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FUTURE NEEDS AND PROBLEMS

AS EVIDENCED FROM THE DISCUSSION TO THIS POINT, MEASUREMENT AND VERIFICATION OF URANIUM INVENTORIES IN A LOW ENRICHED URANIUM FUEL FABRICATION PLANT ARE LARGELY POSSIBLE WITH DESTRUCTIVE AND NON-DESTRUCTIVE METHODS AVAILABLE TODAY. THE RESULTS OF APPLICABLE R&D PROGRAMS HAVE BEEN EFFECTIVELY UTILIZED. A REMAINING DEFICIENCY LIES IN THE VERIFICATION OF FINISHED FUEL ASSEMBLIES, AND THE NEUTRON COINCIDENCE COLLAR DEVELOPED BY LOS ALAMOS APPEARS TO BE A POWERFUL TOOL IN CLOSING THIS GAP. A REMAINING STEP IS TO INTEGRATE THIS INSTRUMENT INTO THE APPROPRIATE POINT OR POINTS IN THE LOW ENRICHED URANIUM CYCLE. THIS BECOMES AN ARPLICATION R&D TASK. TO BE MOST EFFECTIVE, THIS TASK SHOULD BE WORKED JOINTLY WITH THE INDUSTRY AND THE AGENCY.

SIMILARLY, THE FUEL ASSEMBLY SEAL MENTIONED EARLIER UNDER JOINT DEVELOPMENT BY SANDIA AND ISPRA WILL BE ANOTHER IMPORTANT DEVICE IN CLOSING THIS REMAINING GAP. HERE, INDUSTRY COOPERATION HAS BEEN SOLICITED AND USED, AND THE BWR SEAL IS ENTERING ITS APPLICATION R&D PHASE. CLOSE LIAISON AND COOPERATION WITH THE INDUSTRY, INCLUDING THE REACTOR OPERATORS ON WHOSE FUEL THESE DEVICES MUST BE ATTACHED, ARE OF GREAT IMPORTANCE.

THE FUEL ASSEMBLY SEAL AND NEUTRON COLLAR SHOULD PLAY COMPLEMENTARY ROLES, AND BOTH ARE CONSIDERED HIGH PRIORITY ITEMS BY THE AGENCY, THE U.S. AND OTHER STATE GOVERNMENTS. TO BEST INTEGRATE THESE CONCEPTS INTO THE NUCLEAR FUEL CYCLE THE PLANT OPERATORS SHOULD BE INVOLVED.

IN CONJUNCTION WITH EFFORTS TO DEVELOP PRACTICAL SOLUTIONS TO THE VERIFICATION OF THE FLOW OF FINISHED FUEL ASSEMBLIES FROM FUEL FABRICATORS, THE POSSIBILITY OF VERIFICATION BY THE REACTOR ITSELF MAY BE WORTH EXPLORATION. IN CASES WHERE THERE IS INTERNATIONAL INDEPENDENCE BETWEEN THE FUEL FABRICATOR AND THE POWER REACTOR OPERATOR, THE REACTIVITY TESTS NORMALLY CARRIED OUT UPON REACTOR STARTUP AFTER FUEL LOADING SHOULD PROVIDE A USEFUL VERIFICATION OF FRESH FUEL CONTENT. THAT IS, THE TESTS COULD DETECT THE ABSENCE OF A QUANTITY OF SAFEGUARDS IMPORTANCE.

IAEA INSPECTION OF U.S. FACILITIES CAN PROVIDE A PRACTICAL TRAINING GROUND FOR IAEA INSPECTORS AND ALSO CAN SERVE TO DEMONSTRATE TO OTHER COUNTRIES HOW PRACTICAL, COST-EFFECTIVE INTERNATIONAL SAFEGUARDS CAN BE CARRIED OUT. IT MAY BE WORTHWHILE TO CONSIDER SUPPORTING SUCH DEMONSTRATION PROJECTS AT U.S. PLANTS UNDER IAEA SAFEGUARDS, SO THAT EQUIPMENT AND TECHNIQUES DEVELOPED COULD BE MORE FULLY DEMONSTRATED UNDER ACTUAL PLANT CONDITIONS.

CONCLUSIONS

IN CONCLUSION, MADAM CHAIRMAN, OUR ASSESSMENT OF THE IAEA'S VERIFICATION IN OUR EXXON NUCLEAR FACILITY IN RICHLAND, IS THAT THE INVENTORY IN A LWR FUEL FABRICATION PLANT CAN BE VERIFIED BY INDEPENDENT MEASUREMENTS AT A MODEST BURDEN TO THE OPERATOR.

WITH RESPECT TO THE SCOPE AND ADEQUACY OF THE RESEARCH AND DEVELOPMENT PROGRAM TO DATE FOR NDA AND CONTAINMENT AND SURVEILLANCE FOR THE LOW ENRICHED URANIUM CYCLE, I BELIEVE THE POINT HAS BEEN REACHED WHERE THOSE INSTRUMENTS, NOT ALREADY IN USE, CAN NOW BE APPLIED. THUS, THE REMAINING TASK LIES LARGELY IN THE TRANSITION OF THE LABORATORY DEVICES INTO ACTUAL PRACTICAL USE. BROADER INDUSTRIAL PARTICIPATION WILL BE ESSENTIAL IN THIS TRANSITIONAL PHASE, AND SUCH PARTICIPATION SHOULD ASSIST IN GETTING SAFEGUARDS EQUIPMENT AND TECHNIQUES INTO ROUTINE USE DOMESTICALLY AND BY THE IAEA. IN FACT, AS HAS BEEN DEMONSTRATED ALREADY, SOME OF THE NEW INSTRUMENTS, SUCH AS THE LOAD CELL, CAN ALSO BE ADVANTAGEOUS TO THE OPERATOR.

FINALLY, THE OPERATOR-INSPECTOR INTERFACE IS OF EXTREME IMPORTANCE. OUR EXPERIENCE HAS SHOWN THAT A NON-ADVERSARIAL APPROACH WITH MUTUAL CO-OPERATION BEST ENABLES THE REALIZATION OF BOTH THE OPERATOR'S OBJECTIVE OF MINIMUM INTRUSION AND BURDEN AND THE AGENCY'S OBJECTIVE OF EFFECTIVE VERIFICATION. THE SATISFACTORY DEMONSTRATION OF THESE TWO OBJECTIVES SHOULD ALSO AID MATERIALLY IN GETTING ADVANCED SAFEGUARDS SYSTEMS IN USE. IF THE OPERATOR IS MADE TO FEEL THAT HIS CONCERNS ARE RECOGNIZED, THE TASK OF IMPLEMENTING EFFECTIVE SAFEGUARDS IS VASTLY EASIER.

THANK YOU. I'LL BE GLAD TO ANSWER ANY QUESTIONS YOU MIGHT HAVE.

AN OPERATOR'S EXPERIENCE AND LESSONS LEARNED IN IMPLEMENTATION OF IAEA SAFEGUARDS

By

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Exxon Nuclear Company, Inc.
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EXPERIENCE AND LESSONS LEARNED
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ABSTRACT

After 18 months and seven IAEA inspections, considerable first-hand experience has been obtained in the implementation of IAEA safeguards in a U.S. bulk-handling facility. This paper reviews the experience in the Exxon Nuclear fuel fabrication plant and presents examples of lessons learned.

Two important conclusions can be made at this time. First, IAEA safeguards in a low-enriched fuel fabrication plant are not overly burdensome to the plant operator. Second, inventory verification by Agency inspectors can be made to an adequate degree of exactness with a minimum random sample size using largely state-of-the-art measurements.

Of high importance among the reasons for those above results is good communication between the inspectors and the operator. A cooperative, non-adversarial approach is found to offer the best chance of minimizing the burden and improving the efficiency. The inspectors have been willing to consider our needs and suggestions, and we have found the inspectors to be reasonable in their requests.

The unique window that the U.S. inspection effort provides should also assist materially in a better understanding in the U.S. of the IAEA's capabilities and the true burden of international safeguards. As the inspection effort shifts to other U.S. facilities, it is hoped that some of our experiences and learning can be helpful.

BACKGROUND

To encourage widespread adherence to the NPT by non-nuclear-weapons states, President Johnson in 1967 announced that the United States would permit the International Atomic Energy Agency (IAEA) to apply its safeguards to nuclear activities in this country. This policy was reaffirmed by each succeeding president. Early on, the offer enabled some cooperative experimental work at West Valley and Yankee Rowe for IAEA training purposes and to develop techniques and evaluate the burden of safeguards. However, it was not until the agreement between the United States and the International Atomic Energy Agency was ratified by the U.S. Senate on July 2, 1980 and entered into force on December 9, 1980 that the offer became implemented in its more typical form. On February 17, 1981, Exxon Nuclear's fuel fabrication plant was chosen as the first U.S. bulk-handling facility to come under the full safeguards agreement.

After approximately a year and a half of experience and seven inspections, what can one say about this activity? Some question, as may some of you in this audience today, why would the U.S., a weapons state, make such an offer in the first place. Second, why would the IAEA spend its scarce resources to implement it? The U.S. offer was a genuine one. On the one hand, it had a motive to encourage other nations to sign the NPT (which it did), and on the other hand, it was to show that the U.S. nuclear industry was willing to share the same burden being placed on non-weapons states signing the treaty.

Fifteen years after President Johnson's offer, we find ourselves finally entering into the implementation phase of the offer. Has the importance diminished over time? Is there still good to be gained? Is it still possible to benefit? Dissussing these points, we should remember the basic conflict inherent in any inspector-operator arrangement. Can the IAEA's objective of effective verification be reconciled with the operator's desire of minimum burden? Is there an equitable middle ground which meets both of these opposing objectives?

Earlier papers[1,2,3] have discussed details of the inspection effort as the activity has unfolded over time. This paper is not intended to be as detailed an analysis as those and the reader is referred to the earlier papers. Instead, the primary purpose of this discussion is to review the experiences and lessons learned to date in the hope they will be useful to follow-on facilities under the implementation phase of the offer, and to give our preliminary conclusions on the cost and effectiveness of the inspection effort through the unique window which is now open for the first time.

EXPERIENCE

The seven inspections, occurring on the average of once every two months, have included two inventory verifications, each requiring four to six

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1. Herz, E. R., McGinnes, A. J., and Schneider, R. A., "Initial Experience Under IAEA Safeguards", Proceedings 22nd Meeting of the INMM, July 1981, San Francisco, CA.

2. Nilson, R., "Initial Experience Under IAEA Safeguards", paper presented at ANS Meeting, San Francisco, CA, November 29-December 3, 1981.

3. Schneider, R. A. and Herz, E. R., "Implementation of International Safeguards - An Operator's Viewpoint", paper presented at Fifth International Conference on Nondestructive Evaluation in the Nuclear Industry, San Diego, CA, May 10-13, 1982.

days and five shorter inspections involving various nondestructive measurements, observation of our measurements, selection of random samples and audit of our records and reports.

Verification of our inventory statement of nuclear materials is made by the inspectors using an attribute-variables sampling plan. This type of random sampling can detect with high probability the absence (or overstatement) of a quantity of nuclear material of safeguards importance from the plant's inventory. The inspector's attribute sample sizes for the inventory verifications were based on a goal quantity of 75 kg of U-235 contained and a sampling probability of 0.95 of including at least one gross defect in the sample. The variables sample sizes were approximately one fifth as large as the attribute sample size. The sampling method is further able to detect whether the goal quantity had been removed by taking a small number of whole items, by partially taking material from many items, or by taking a small amount of material from a number of items.

Enrichment of our starting material UF_6 is verified with a germanium detector[4]. An ultrasonic thickness gauge is used to measure the wall thicknesses of the steel UF_6 cylinders to correct for gamma ray attenuation. Enrichment and uranium element composition of UF_6 are also verified from samples taken from the UF_6 line during processing.

The inspectors verify the weight of fuel pellets by witnessing our reweighing of them. Pellet samples are also selected for measurement of U and U-235 later at the IAEA laboratory.

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[4] Germanium Detector and Preamplifer, Princeton Gamma Tech., Model JGC12.

For UO_2 powder verification, the inspectors use our SAM-2[5] enrichment meter as an attribute test. The selected buckets are first weighed and then machine tumbled to mix the material prior to the enrichment measurement. The tumbling insures that any substituted inert materials would be detected, since the SAM-2 as used only detects the gamma rays coming from the UO_2 in the bottom of the bucket. A fraction of buckets is sampled for U and U-235 analyses later at the IAEA laboratory. These samples serve as "independent" standards for the SAM-2 enrichment meter and also provide the data for the variables test. The independence of the sampling is preserved by completing the UO_2 enrichment measurements on all of the buckets selected for the attribute test before any buckets are identified for sampling for the later destructive analyses.

Fuel rods are randomly selected for verification and are measured for total fissile count with our active rod scanner[6]. Approximately 50 fuel rods need be scanned for a complete inventory verification. The rods are compared against full length "standard" rods selected from reject or excess rod inventories matching the rods tested. A few of the "standard" rods are downloaded in the presence of the inspectors and their fuel pellets are removed for weight verification and later destructive analysis at the IAEA. The majority of the rods are matched by standard rods and can be considered as measured by a variables method. A smaller number of rods (∿ 20%) not matched with standard rods can still be considered verified from an attribute standpoint (to within ± 15%). The weights of pellets removed from the rods closely matched our stated weights of the fuel pellet columns originally loaded into the rods, and the enrichment verifications in the first inventory verification matched our values within a few tenths of a percent.

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5. Model SAM-2 Enrichment Meter, Eberline Company, Santa Fe, NM.

6. Active Fuel Rod Assay System, National Nuclear Corporation, Campbell, CA.

Two new instruments have been tested. One is a load cell[7] which fits on our crane attachment and allows the inspector to independently weigh UF_6 cylinders. The load cell has proved very useful to us as well, as it permits UF_6 cylinder weighing in situ, rather than having to move them to a central scale. The second device tested is the Los Alamos developed neutron coincidence collar[8] attachment for nondestructively verifying fuel assemblies.

The direct interaction with the Agency's inspectors has provided several opportunities to minimize the burden, and several of the measurements just described were innovations jointly evolved during the course of the inspections. However, unexpected benefits or spinoffs have also resulted which are important to both the operator and inspector. For example, the field testing of new instruments has demonstrated at least one new practical measurement method whose adoption by plant operators can increase their efficiency, e.g., the load cell weighing device for the crane.

LESSONS LEARNED

As stated earlier, the sharing between the operator and inspector of procedures, techniques and equipment have been mutual learning experiences which have reduced the effort and increased the effectiveness of the inspection. It is of interest to review some of the lessons learned.

It is important that the inspector be able to verify that all of the inventory items claimed by the operator are actually present. A 100% item count is not practicable, nor needed; the total number of items can be verified randomly. But this can only be done validly if the inspector is first given a list of the individual inventory items for selecting his samples.

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[7] Load Cell Based Weighing System, BLH Electronics, Waltham, MA.

[8] Menlove, H. O., "Description and Performance Characteristics for the Neutron Coincidence Collar for the Verification of Reactor Fuel Assemblies", LA-8439-MS, Los Alamos National Laboratories, Los Alamos, NM, August 1981.

It is also necessary that the inspector be assured that the operator's final inventory listing (after reconciliation) is the same as that provided earlier prior to verification. After the inspection, the operator knows which items the inspector has verified. If later, in the final listing sent to the inspector, he alters the values of the items not verified by the inspector, the verification is meaningless. Of course, to counter this, the inspector could have recorded the values of all inventory items, but this would be time-consuming and is desired neither by the operator nor the inspector. A practical solution is to both provide the inspector the inventory list prior to his verification and a final inventory listing after reconciliation. The inspector can then make a one-to-one comparison between the two lists to assure that the final inventory listing is consistent with the initial list and that the inventory item values sum to the correct totals.

To carry out this procedure, the inspectors are provided with copies of our physical count sheets after we complete our physical inventory for each inventory location. These count sheets represent our provisional statements of the number of items present at each location, their individual identities, and their uranium and U-235 content.

The items on the physical count sheets are also arranged in numerical sequence by inventory sticker number and the stickers are applied by our inventory teams in order of physical location. This has made it easy to find the items selected for verification.

The inspectors have not yet been fully receptive to our two-list approach, but since U.S. regulations allow 30 days to close out an inventory and reconcile the books, there is no easy way to provide the inspectors with a final inventory list before they leave the plant; usually less than a week after the start of our inventory taking. We feel the solution described to this problem is fully equivalent and provides the necessary assurances against falsifications.

An alternative to this two-list approach (provisional and final) would be for us to complete our physical inventory, "freeze" it, and then reconcile and finalize the inventory before the start of the inspector's verification, so that a finalized list could be provided to the inspectors prior to their verification. But, this is impractical in our case, since it would require a one-to-two week "inventory freeze" and plant shutdown before the IAEA could start their verification.

No anomalies have been reported to us by the inspectors in either inventory verification. The inspectors have found minor discrepancies between our records and reports and the information received in Vienna via the U.S. Information System (NMMSS). We are in the process of resolving these discrepancies with the NRC and Oak Ridge NMMSS staffs.

Then of course, there have been the many effective mutually developed verification techniques using both Agency and operator measurement methods which have already been described.

COST-EFFECTIVENESS

The main burden experienced is the manpower for escorting inspectors, locating items for verification measurements, performing verification measurements, preparing accounting reports and inventory lists, and providing incidental services. Over the eighteen months to date, this manpower cost equates to less than 15 cents per kilogram of fuel produced in the plant, which is a small fraction of the total cost of producing fuel for LWR's.

We had early concern over the potential for lost production time while the inspectors completed their verification or having to slow or halt production in certain areas so that IAEA verification measurements can be made. This has also not proven to be a problem. In addition to the "two-list" approach already discussed, we have scheduled our inventory taking near a normal production break (e.g., a weekend), so that the inventory verification by the inspectors could be carried out during a normal production break. The IAEA inventory verifications have thus been able to be completed with only a few hours of lost production.

The technical and procedural innovations previously discussed have also proven useful in increasing the efficiency of the verification effort. We estimated that the use of our rod scanner saves approximately four man-days of inspector-operator time per inventory verification compared with a "manual" scan of fuel rods with a passive gamma counter. Likewise, the use of the SAM-2 enrichment meter for the attribute test has reduced the variables sample size by a factor of three from what it would have been if the variables method (weighing, sampling, and analysis) had been used in total. The load cell for weighing UF_6 cylinders has reduced considerably the time to verify UF_6 weights and is a practical device that may also be useful to us. The neutron collar for fuel assemblies enables for the first time the verification of final product, and from the test results to date, the neutron collar should be quite effective.

Our observations to date have shown that all available inventory items in a LWR fuel fabrication plant can be efficiently verified by independent measurement with an adequate level of exactness. Our values for the contents of sintering boats and trays of UO_2 fuel pellets and containers of uranium oxide powders are verifable to a sufficient degree of quality by weighing, sampling, U-assay, and U-235 mass spectrometric measurements. Combined operator-inspector measurement uncertainties (one sigma level) can be held to 0.1 - 1.0 percent relative. The use of our rod scanner provides a verification uncertainty as small as 1-2 percent for fuel rods, and the independence needed can also be provided.

The enrichment of UF_6 in cylinders can be verified adequately by non-destructive means. Calibration of detectors using cylinders of known enrichments as standards can reduce verification uncertainties for enrichment to only a few percent (one sigma) relative.

An operator's SAM-2 enrichment meter is very valuable in providing the inspector a "gross defect" check for UO_2 containers. Opening a fraction of the containers for visual inspection and sampling for U-assay and U-235 by mass spectrometer provides "independent" standards, and the tumbling protects against material substitution.

The results of tests made on both BWR and PWR fuel assemblies with the coincidence neutron collar were good. The measured enrichment of fuel assemblies agreed with our values within a few percent. Details on how the collar will actually be used in a fuel fabrication plant has not been finally worked out.

One of the important benefits of the implementation of the U.S. offer is that for the first time full fledged IAEA inspections are occurring in the U.S. A window which has never been available before is now open.

SUMMARY AND CONCLUSIONS

It has been demonstrated that significant progress has been made in achieving efficient and cost-effective international safeguards inspections in a bulk-handling facility. Much of the success has been due to the desire on both the operator and inspector to cooperate with each other. Success has also been due to introduction of innovative approaches by both the operator and the inspector. Under such circumstances, the burden of safeguards can be acceptably low without sacrificing the Agency's objectives of adequate safeguards verification.

The operator can further control his burden by maximizing the "verifiability" of his inventory. Cooperative efforts between the inspector and operator in planning, scheduling, and coordinating the combined activities of inventory taking by the operator and inventory verification by the IAEA, are able to virtually eliminate lost production time. Non-destructive assay instruments also play an important role in the efficiency and effectiveness of IAEA verification.

Mrs. **Bouquard**. Thank you, gentlemen, for the very valuable testimony on industrial participation. It has been most enlightening.

Dr. Buckham, how much was IAEA involved in the planning and conduct the safeguards R&D programs at Barnwell?

Dr. **Buckham**. We have had considerable interaction with the agency. They have been aware of what we are doing and we have informed them. We have also performed some training courses for the benefit of members of the agency at their request. Mr. Bambas might be able to elaborate a little further on that.

Mrs. **Bouquard**. Mr. Bambas?

Mr. **Bambas**. Yes, AGNS staff has served as instructors in the inspector training program in accountancy that has been mentioned by the other speakers, and also we have independently worked with the IAEA, providing guidance to the training program development staff in Vienna and later providing a training program scenario and sending our people to Vienna to work with the IAEA staff and train the trainers who are presently working in Vienna.

Mrs. **Bouquard**. You stated that IAEA enthusiastically endorsed the system that has been developed. I think you also said that you had a letter from the Deputy Director as to the fact that they wanted to cooperate with you in the planning and implementation. What has been the impact of their involvement in this area?

Dr. **Buckham**. Yes, Madam Chairman. In fact, I believe we appended to our written submittal that letter from Dr. Gruemm. What they have primarily done is endorsed the need for a full-scale demonstration of the Barnwell system, which is what the Department of Energy plans for 1983, saying that that would be the best means they know of—I am paraphrasing—to get from here to their desired goal of implementing effective safeguards in reprocessing plants throughout the world.

Mrs. **Bouquard**. Have they given you any indication they are willing to contribute financially?

Dr. **Buckham**. No, that they have not pointedly done. Of course, we are a large financer of them. It may be just going around in circles, were that to happen, but I know that they have a limited budget and they have have not offered to finance such an operation but they are enthusiastically awaiting the outcome of such a demonstration.

Mrs. **Bouquard**. Your budget for 1983 is $10 million. Of this $10 million, how much is actually needed to complete the 2- or 3-month sustained operation necessary for international acceptance?

Dr. **Buckham**. Madam Chairman, virtually all of that $10 million item would be, if approved by the Congress, used for this demonstration; at least $9.5 million and maybe a little more. However, as in the past, we would probably do other contracted work for the Department of Energy that is funded separately.

Mrs. **Bouquard**. Well, as long as we are talking about the money part, what are the prospects of receiving funds from Japan or West Germany for the test? Do we have any firm commitments?

Dr. **Buckham**. We are still working on that, and we have had no commitments but we remain hopeful.

Mrs. **BOUQUARD**. If foreign funds are invested, what are the implications of this investment to foreign access to the reprocessing technology that we are developing at Barnwell?

Dr. **BUCKHAM**. What the foreign funds would be used for is to pay for the costs of demonstrating this system for their benefit so that they could incorporate it into the design of their plants. I would not really refer to it as an investment in our facility in any way. That can be done, and I would like to ask Mr. Bambas to elaborate on it, completely without revealing any sensitive nuclear technology, as has been surmised to be the case by some.

Karl, could you elaborate?

Mr. **BAMBAS**. Yes. I think there is one interesting comparison between the technology for reprocessing that exists at Barnwell, for example, and the gaseous centrifuge technology that is being currently developed and does represent sensitive nuclear technology. Reprocessing has, since the middle 1950's, been an internationalized bit of technology. In the 1950's there were international seminars in which the Purex process technology moved overseas. There have been a number of reprocessing plants operated, in operation now, and under construction, using the same Purex technology that we employ at Barnwell.

Therefore, we see that there is not really sensitive nuclear technology existing at Barnwell which would in any way be jeopardized or could in any way move overseas. The technology at Barnwell has been based on the Purex experience from around the United States and around the world. We have equipment at Barnwell which was acquired in technology exchange agreements from the British and from the French.

Also, the technology at Barnwell will be protected during these demonstrations in the sense that the plant will be operated as close to simulation of hot operation as possible. We will close and lock the cells. People will not be going inside, adjacent to the process equipment, during the demonstration. We will operate the plant from the control room as we would if we were in hot operation and so, as best we see it, there is not really any danger of any sensitive nuclear technology moving outside of the United States.

Mrs. **BOUQUARD**. Let's turn a little bit to timing. Our last panel commented on the need for plant design and safety factors. When will such a system test provide the results? Will they be provided in time that they can have the maximum influence on foreign design of reprocessing plants?

Dr. **BUCKHAM**. Yes, Madam Chairman, if it is done in 1983. The French are actually clearing land for their plant, the British are starting their design and have selected a site, and in the case of Germany and Japan they are still selecting a site and have not yet started design, so the timing is absolutely perfect for maximum effectiveness if it is performed in 1983. If performed later, the more the delay the less the likelihood they would be able to incorporate it into the smooth design of their new facilities without difficulty.

Mrs. **BOUQUARD**. In other words, this $10 million is pretty important.

Dr. **BUCKHAM**. I sure think so.

Mrs. **BOUQUARD**. I certainly do, also.

I think that we do have a role to play, and you are participating in the development of the peaceful use of nuclear power for all mankind. I certainly applaud you for the great work that you are doing.

Dr. Nilson, what impression did you form about the professional capabilities of the IAEA inspectors?

Dr. NILSON. We have had very good inspectors. We have had inspectors from maybe six or seven countries, including Algeria, Spain, Italy, Germany. I was very impressed at the last inspection with a Greek inspector who had spent 1 week at Los Alamos learning how to use the very complex neutron coincidence counter, and he was able to use it in our plant without disrupting us.

Mrs. BOUQUARD. How much did you have to teach them before they could operate the equipment effectively?

Dr. NILSON. It is a very complicated instrument. They have to be taught how to run it, turn it on, interpret the results, take the data and calibrate it and standardize it and so on. This teaching was done at Los Alamos. I was very impressed with his ability to learn it. He was very impressed, also, with the instrument. I was pleasantly surprised. There are only seven inspectors available for the the whole U.S. offer, and that also includes Great Britain and one other country. We probably see some of the more experienced inspectors.

Mrs. BOUQUARD. I believe you stated that they did not interfere with your production line.

Dr. NILSON. Well, they would like to interfere more. We have held them off to the point where what they have received is still effective, but we have tried to maintain a balance between our cost and their needs. This has been worked out by utilizing some of the cost-saving innovations I discuss in my paper. The inspectors were appreciative of that and so were we.

Mrs. BOUQUARD. I think you also commented on the instruments that you had perfected. Did——

Dr. NILSON. We have not perfected them. The laboratories——

Mrs. BOUQUARD. That are in a state of being perfected.

Dr. NILSON. Right.

Mrs. BOUQUARD. Did the IAEA inspectors bring their equipment with them?

Dr. NILSON. Yes. They have brought their germanium detector with them and they brought the coincidence collar with them. They have stored both of those, now, at our plant. They also originally brought their own SAM-2 but they found they could use ours, and independently calibrate it as a standard, and that saved them the task of bringing their own equipment.

Mrs. BOUQUARD. Dr. Nilson, as an observer of nuclear safeguards as a whole, what do you think are the problems that are in the most urgent need of attention?

Dr. NILSON. Plant design is certainly important. Our plant was designed later than some of the earlier plants, at a time when Dr. Thornton was in charge of the AEC safeguards and he enforced high standards so we were able to incorporate into our plant some of the advanced measurement techniques. Design in the first phase of a bulk-handling facility is very critical for safeguards. You must have adequate design criteria at the beginning, and it is difficult to retrofit later on.

In the area of accountancy versus containment surveillance, I think the two concepts need to be used together and can complement each other and allay many of the concerns about the inability to adequately account for nuclear materials.

Mrs. **Bouquard**. Would you gentlemen comment on the need for additional inspector training? Do you think we are adequately addressing this problem?

Dr. **Nilson**. I think more training is needed, and the United States and other countries are providing this training. We have provided formal training in our facility for State safeguards personnel, as I mentioned earlier. Inspector training by us to date has been incidental to the inspection activities in our plant.

Mrs. **Bouquard**. Thank you very much.

Mr. Lujan?

Mr. **Lujan**. Thank you, Madam Chairman.

Let me follow up on that: Is the agreement that you have with IAEA primarily one of training the inspectors? Is that basically what it is?

Dr. **Nilson**. We do not have an agreement with IAEA. We assist the laboratories in the formal training exercises provided to date.

Mr. **Lujan**. Who has the agreement? DOE?

Dr. **Nilson**. DOE I believe has the agreement and the training is administered through the Los Alamos National Laboratory.

Mr. **Lujan**. They send them around to——

Dr. **Nilson**. In the formal training programs, our plant is used as part of the actual, physical demonstration of a plant.

Mr. **Lujan**. However, it is primarily training?

Dr. **Nilson**. It is training, right.

Mr. **Lujan** [continuing]. Of the inspectors?

Dr. **Nilson**. The inspector training has not yet been a part of the formal training program—only the actual in-plant experience gained during the inspections.

Mr. **Lujan**. You say that seven inspectors is——

Dr. **Nilson**. Well, we have had training of more than that in the formal training programs for State personnel.

Mr. **Lujan**. The IAEA.

Dr. **Nilson**. Right, and State safeguards personnel.

Dr. **Buckham**. They have similarly used the Barnwell plant in that same training exercise, and there have been 40 or 50 foreign nationals involved in the training sessions at Barnwell.

Mr. **Lujan**. Let me ask you, if we are going to have a safeguards program in Japan at their new plant in a hot operation, why Barnwell, then? Isn't it better to have your program right at the place that is operating?

Dr. **Buckham**. Well, no; because there are certain remaining developmental activities that are best done in a plant that has not yet reprocessed nuclear fuel. I think Mr. Bambas is in a good position to compare the good work that is being done at Tokai Mura as compared to the good and necessary future work being done at the Barnwell plant. They harmonize rather than conflict.

Mr. **Bambas**. The work that has been done as part of the TASTEX program at Tokai Mura has been largely in the development and installation of instruments for making improved measurements, making measurements more accurate. The Tokai Mura plant still, in conducting an inventory of its special nuclear material, would do so on a multimonth basis—in other words, take an inventory after campaign shutdowns or at least about once every 6 months.

What has been done at Barnwell is to take that same instrumentation—some of which, by the way, was transferred from Barnwell to Tokai Mura through the TASTEX program—and integrate it, such that we have in excess of some 500 instruments in our plant connected, hard wired to a computer, and as Dr. Buckham pointed out we can run an inventory on the plant as often as once every hour. When you can take an inventory that often, it is possible to detect diversion at a much more sensitive level than you can if you take an inventory once every 6 months.

Mr. LUJAN. Let me get down to the reprocessing end of it. You hear all kinds of reports—as a matter of fact, one from Argonne—that Barnwell is not well designed to go into reprocessing. You hear that because it is too expensive anyway, there is no need to do it. Please comment about that. Give me some of your thoughts on that.

Dr. BUCKHAM. Yes, there have been some derogatory reports about some people's opinions on the operability of the Barnwell plant. There also has been a great deal of misinterpretation of the opinions that have been expressed. For example, in the Argonne report the original criticism leveled at the Barnwell plant was whether or not it could reprocess 100,000-megawatt-day-per-ton fast breeder reactor fuel promptly, within 30 days. Well, that plant was never designed to do that job and should not ever be asked to do it and I agree with their conclusion that it is not well-suited to that task.

On the other hand, it was designed to process light water reactor fuel exclusively, and the teams of experts that have reviewed the plant have said yes, it can do that and do it with a high operating factor. There was a recent, I would call it unfortunate, report released that was derogatory about the whole idea of reprocessing and very misinformed on the economic aspects. Your chairman has described it in the Congressional Record as "full of utter falsehoods." I agree with you, Madam Chairman. I think what it mainly consists of is misleading interpretations of partial facts, in an inappropriate way.

Mr. LUJAN. A thing that was designed to do a particular job but the studies are about doing some other job that it was not designed to do?

Dr. BUCKHAM. Yes, that is quite often what happens, and the average reader does not recognize the nuance, the vital difference between the two.

The author of that one report downrated the Nuclear Fuel Services plant performance because it processed a lot of low-burn-up defense fuel in the course of its early years, where as a matter of fact it was with that fuel they had the most problems. I do not agree with hardly any of the interpretations in that report.

Mr. LUJAN. We have to go vote but first what about the financial end of reprocessing?

Dr. **Buckham**. Reprocessing is still a lower-cost route than the throwaway cycle, and it is a lower cost route than involving yourself in interim storage but I would like to make it clear that the value of the recovered products, the plutonium and uranium, as fuels, do not quite cover the total cost of reprocessing today as they used to because of the lower current prices of uranium. Even so, it is still the most economic route and one that gets a much better job done.

Mrs. **Bouquard**. Since we do have two votes and the second one is a 5-minute vote, we will stand in recess for approximately 20 minutes.

Do you have further questions of this panel?

Mr. **Lujan**. No, Madam Chairman.

Mrs. **Bouquard**. We certainly thank you gentlemen.

When we resume our hearings we will hear from Dr. Muntzing. Thank you very much, gentlemen.

[Recess taken.]

Mrs. **Bouquard**. We will resume our hearing. I do want to apologize for the delay but it is one of the inevitable responsibilities, and something always happens in the midst of our hearings.

We do want to welcome you, Mr. Muntzing, and congratulate you on your election as president of the American Nuclear Society. We have your complete testimony. You may summarize or proceed as you wish, but your entire testimony will be made a part of the record.

[A biographical sketch of Mr. Muntzing follows:]

L. MANNING MUNTZING

Born Harrisonburg, Virginia, June 24, 1934. Admitted to the District of Columbia, Maryland and West Virginia Bars 1960. Preparatory education, University of North Carolina (A.B. 1956), Phi Beta Kappa; Woodrow Wilson School for Public and International Affairs, Princeton University; Harvard University Law School (LL.B. 1960). Counsel, Chesapeake and Potomac Telephone Companies 1960–71; director of Regulation, United States Atomic Energy Commission, 1971–75. Member: Editorial Advisory Board, Progress in Nuclear Energy, International Review Journal, 1976 to present. Member: Board of Trustees, National Presbyterian Church, 1977 to present. Member: the Bar Associations of the District of Columbia, State of Maryland, State of West Virginia, Federal Bar Association (Chairman: Atomic Energy Committee 1975–76; Council on Science, Technology and the Law Section 1976–79), and the American Bar Association. Member: American Nuclear Society, Board of Directors and Executive Committee, 1977–81; President 1982–83; ASTM (Member, Research and Technical Planning Committee 1976 to present, Chairman, 1978–80). Editor of International Instruments for Nuclear Technology Transfer.

STATEMENT OF L. MANNING MUNTZING, PRESIDENT, AMERICAN NUCLEAR SOCIETY

Mr. **Muntzing**. Thank you, Madam Chairman.

It is a pleasure to be here on behalf of the American Nuclear Society, of which I am the president. The American Nuclear Society is a technical, scientific, and educational organization composed of 13,000 people from universities, laboratories, Government, and industry.

In the process of our considerations, we prepare public policy statements and we have prepared one that is relevant to this subject, dated September 1981 and entitled, "United States Post-International Nuclear Fuel Cycle Evaluation [INFCE] Policy." Madam

Chairman, I would like to ask that that statement be included in the record.

Mrs. BOUQUARD. Without objection, this policy statement will be made a part of your testimony, included in the record.

Mr. MUNTZING. Thank you very much.

There are two recommendations from that statement that I would like to emphasize for the subcommittee. First, the American Nuclear Society recommends that the administration take the steps needed to define its program for improving internationally acceptable safeguards and demonstrating application and surveillance of such safeguards through the International Atomic Energy Agency.

Second, the ANS further recommends that the U.S. Government, in close cooperation with the nuclear industry, take the initiative in establishing regional, international, or multinational institutional solutions for sensitive fuel cycle services that would provide supply assurance to all nations at reasonable cost for such services.

The conclusions of the American Nuclear Society in this position paper are as follows:

First, the concerns regarding proliferation can now be resolved with international cooperation on safeguards and the development of appropriate institutional arrangements through the leadership of the United States.

Second, the United States should take a necessary step to restore the domestic nuclear option by accepting and implementing the findings of INFCE.

Third, the Government should also take the actions recommended to restore credibility and leadership in international nuclear policy as a reliable supplier, and in safeguards development by signaling attention to the INFCE results and acceptance of the INFCE findings.

The INFCE findings, which are supported by the ANS, relating to safeguards include the following:

First, INFCE concluded that "Proliferation is primarily a political, and not a technical, matter" and that international measures already exist to reduce the risk of proliferation.

Second, INFCE minimized concerns regarding the use of the commercial nuclear fuel cycle as a route to proliferation. The evaluation stated,

> The construction and planned misuse of fuel cycle facilities is not the easiest nor the most efficient route to acquire materials for the manufacture of nuclear weapons.

and that,

> The use of commercial grade plutonium is an unattractive route to the manufacture of nuclear weapons as compared with weapons grade plutonium produced by a dedicated program.

Third, INFCE found with respect to fuel cycle services that, "means exist to minimize the danger of misuse of fuel cycle facilities—including technical measures, improved safeguards, and institutional arrangement."

Fourth, technical measures by themselves have only a limited ability to reduce proliferation risk. However, institutional arrangements were seen as contributing importantly to minimizing proliferation risks and to establishing assurance of supply.

Fifth, INFCE concluded that improved safeguards can minimize proliferation. This view was expressed in the following observations:

> Further development and improvement of existing methods and techniques were foreseen as necessary to meet safeguards objectives at reasonable costs, in connection with technologies for uranium enrichment, industrial-scale reprocessing or irradiated fuel, and mixed oxide fabrication for LWR's or breeder reactors.
>
> For future reprocessing and mixed oxide fuel fabrication plants, it will be essential to take full account of criteria for effective international safeguards.

This testimony that I have given reflects the official position of the American Nuclear Society. It is, however, possible to add to these basic concepts by way of example and description. The discussion that follows, therefore, is not a part of the official ANS position, but it is my belief that it is consistent with and illustrative of the general principles officially approved by our society.

Nonproliferation objectives can be achieved through a combination of institutional arrangements, safeguards, and technical measures. While the statements that follow emphasize safeguards and technical measures, institutional arrangements are particularly important and should not be deemphasized.

The IAEA, for instance, has under consideration a variety of initiatives such as international plutonium storage, international spent fuel management, and the committee on assured supply. In addition, ideas such as the leasing of nuclear fuel could also contribute to nonproliferation objectives.

In order, though, for the institutional systems to function effectively, it is essential that there be a credible safeguards system. The International Atomic Energy Agency has established a system of safeguards designed to assure that nuclear materials are being used only for civilian purposes, and supporting that program are measurement equipment and verification techniques.

During the past decade, as you have heard from other witnesses, there has been a substantial effort worldwide in research and development of new instrumentation and techniques for verifying the identification, location, and quantity of materials. As a result of this effort in the past few years, there is now at this time a need for extensive applications engineering in consort with the operators of facilities to insure practical application of their instrumentation in all countries.

For instance, the proposed expanded tests at Barnwell which you have heard about this morning could add significantly to our knowledge on the use of advanced safeguards technology. Further, there is a great need for the establishment and support of an infrastructure for the maintenance and repair of instrumentation. Of particular importance is the development of reliable sources for spare parts. Regardless of how effective an instrument may be, if it cannot be relied upon, if its repair is not simple with readily available spares, it will gain little acceptance by the inspectors and see little application.

There is a continuing need for miniaturization of equipment. Inspectors have commented that it is difficult to take into the field all the equipment which is available to them. If the function of the instrumentation can be incorporated into smaller, lightweight, rugged containers without compromising the sensitivity and reliability of the instrumentation, it will obviously improve the acceptability and use of the equipment.

Proper training is also an important ingredient in the application of the techniques and equipment which have been developed. There needs to be more emphasis and attention devoted to training at the IAEA, particularly under realistic circumstances. Inspectors need to be trained on the equipment in real environments under typical field conditions. There have been developed new training methodologies which the Agency should adapt to its programs. This is particularly important at the IAEA because of the high turnover of the inspectors.

Typically, the assignment of an inspector to the IAEA is for a 2-year period with the possibility of an extension. It generally takes about a year for the inspector to become accustomed to his role as an inspector, and he may not become fully efficient or effective in his role until he nears the end of his second year, at which time he is preparing to leave the agency. I think the agency should review its policy of short-term appointments and explore the desirability of longer-term appointments for inspectors.

Ideally, there should be established an academy for prospective inspectors to provide them with a good and common foundation with regard to the use of safeguards techniques and equipment. The curriculum should include frequent trips into the field to apply the knowledge imparted under realistic circumstances. Upon graduation from the academy, the prospective inspector should be given an appointment of sufficient length that the investment by the IAEA can be reasonably amortized. An appointment of at least 5 years seems reasonable in order for the agency to take full advantage of the training and experience that the inspectors gain.

Standard reference materials are needed for calibration of field and laboratory equipment and to support quality control and quality assurance programs. Not only is there a need for standards development but equally important is the need for a reliable supply program so that the standards can be used. In the past there has been a inadequate support for standards programs. Domestically, there have been occasions when the lack of a supply of standard reference materials has adversely affected the domestic safeguards program. Licensees, for instance, have had to ask for waivers from the NRC of quality control requirements because standard reference materials were not available.

There is also a need for standardization in the manner in which data is generated, aggregated, and processed. Today, there is a flood of data into the IAEA but because there are not adequate standards appliable to its generation, there is extreme difficulty in analyzing the data in a meaningful manner. Without standardization, comparisons can be meaningless and analysis can be misleading.

The IAEA needs encouragement to further its surveillance and containment program. In support of that program, there is a need for development of improved integrity and reliability, including redundancy of surveillance devices such as cameras. Storage and retrieval of the information needs to be improved so that the information can be acquired in an easy and timely manner. Although effective security seals presently exist for many applications, a major effort is needed to develop a new generation of rugged and inexpensive seals which can reliably operate in a hostile environment, such as fuel assemblies in an operating reactor. Of utmost importance is simplicity of attachment and ease of verification.

To discuss the needs of the safeguards program of the International Atomic Energy Agency is not to denigrate in any fashion the accomplishments of the agency or to minimize the importance of its current activities. Establishment of the IAEA was a significant accomplishment in international relations. Moreover, the IAEA safeguards program is unique because it requires sovereign nations to open their nuclear facilities and records to international inspection, a concession which is unparalleled in history. That so many nations of the world have accepted reliance upon the agency's safeguards program is indeed a noteworthy accomplishment, and I think the figure stands at the moment at 116 nations that have signed the Non-Proliferation Treaty.

Unfortunately, much of the inspectors' activities and the results of inspections are cloaked in secrecy, a fact which undermines the credibility of the safeguards program. The IAEA safeguards program can provide a window on the utilization of fuclear materials in participating nations. Each nation should recognize that fact and should take advantage of that window to display its good intentions for the world to see. Consequently, we should be encouraging all nations to reassess their demands for secrecy with regard to the Agency's activities and to encourage an open record of those activities.

At the same time, nations may have commercial information which they wish to protect. Therefore, progress toward application of safeguards in an effective manner at the perimeter of facilities is a desirable goal. Achievement of this goal may convince some nations to place under IAEA safeguards facilities which contain such information.

The improvements to the IAEA program described above will enhance the IAEA ability to detect diversion or changes in normal operation. As such, they constitute a restraint to the civilian nuclear power program being a source of nuclear weapons material. In addition to the safeguards system and their effective implementation, it has been suggested that nonproliferation objectives would be further achieved through research concerning technical measures such as supplying fresh fuel in a denatured fashion so that diversion is further discouraged. This was the purpose of the CIVEX proposal made several years ago.

Another concern is somewhat in a twilight zone between institutional and technical arrangements. This involves the issues associated with resource accumulation of dual-use materials. These are areas where useful research and analysis could further contribute to nonproliferation objectives.

Supplier nations have cooperated to a substantial degree in identifying items which should be subject to export controls. To date, however, the lists of restricted items have generally included only those materials, components, or technologies which are clearly intended for use in sensitive nuclear facilities. In recent years much attention has been given to presumed efforts by some nations to import uncontrolled items which, in addition to their normal innocuous uses, can also have uses in enrichment or reprocessing plants.

Some of these dual use items are so common that it would be virtually impossible to subject them to meaningful control. This may not be true of all, however, and supplier nations should make a determined effort to identify those commodities which have a clear application in sensitive nuclear facilities and for which controls may be feasible. Failure to make this effort would leave the supplier nations open to the criticism that they have turned a blind eye to an important proliferation problem.

A combination of improved safeguards and effective implementation, attention to technical constraints and institutional arrangements can assure that peaceful nuclear uses do not contribute to nuclear weapons. This means the programs must be conducted so that the risks associated with peaceful uses, whether they be risks to health, safety, and the environment or risks related to weapons proliferation, are contained at very low levels and perceived by the public to be acceptable.

Even with technical solutions, safeguards controls, and institutional arrangements, a fundamental point that must be kept in mind is that the most important step to peace and stability throughout the world is to remove the motivation for war. One such possible motivation stems from the fact that nature did not distribute oil, gas, coal, or uranium evenly around the world. Most nations do not have sufficient energy sources of their own. One of the ways to remove this motivation for war is to have assured supplies of energy. Nuclear power, rather than being a contributor to war, will help to achieve peace through providing energy to resource-deficient countries.

A good bargain represented by the NPT has been reached in the world between nuclear weapons and nonweapons nations, namely that nuclear weapons are to be controlled and reduced while nations receive peaceful nuclear benefits. It is the renowned concept of "swords into plowshares." In addition, peaceful nuclear benefits can help remove one of the motivations for war and be a force for nuclear weapons control. The antinuclear weapons forces should be in the forefront of those advocating peaceful nuclear uses, and the supporters of peaceful uses should support controls and reductions of nuclear arsenals.

Thank you very much, Madam Chairman.

[The prepared statement of Mr. Muntzing follows:]

STATEMENT

By

L. MANNING MUNTZING, President
AMERICAN NUCLEAR SOCIETY

"TECHNICAL ASPECTS OF NUCLEAR NON-PROLIFERATION: SAFEGUARDS"

Before

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
COMMITTEE ON SCIENCE AND TECHNOLOGY
U. S. HOUSE OF REPRESENTATIVES

August 4, 1982

Chairman Bouquard and Subcommittee Members:

My name is L. Manning Muntzing, President of the American Nuclear Society (ANS), located at 555 North Kensington Avenue, La Grange Park, Illinois 60525. The ANS, founded in 1954, is a not-for-profit scientific, technical and educational Society of 13,000 scientists, engineers and educators from universities, government and private laboratories and industry. We appreciate the invitation to participate in these hearings on the "Technical Aspects of Nuclear Non-Proliferation: Safeguards".

The American Nuclear Society formally states its positions by the use of Public Policy Statements that are the considered opinions and judgments of the Society in matters related to nuclear science and technology. These Public Policy Statments are intended to provide an objective basis for weighing the facts in reaching decisions on important national issues. Attached to my testimony is a Public Policy Statement of the ANS entitled "United States Post-International Nuclear Fuel Cycle Evaluation (INFCE) Policy" dated September 1981. Two recommendations from that Policy Statement are particularly relevant to these hearings:

1. The ANS recommends that the Administration take the steps needed to define its program for improving internationally acceptable safeguards and demonstrating application and surveillance of such safeguards through the International Atomic Energy Agency (IAEA).

2. The ANS further recommends that the United States Government, in close cooperation with the nuclear industry, take the initiative in establishing regional, international, or multinational institutional solutions for sensitive fuel cycle services that would provide supply assurance to all nations at reasonable cost for such services.

The conclusions of the American Nuclear Society in this position paper are as follows:

1. The concerns regarding proliferation can now be resolved with international cooperation on safeguards and the development of appropriate institutional arrangements through the leadership of the United States.

2. The United States should take a necessary step to restore the domestic nuclear option by accepting and implementing the findings of INFCE.

3. The Government should also take the actions recommended to restore credibility and leadership in international nuclear policy as a reliable supplier and in safeguards development by signaling attention to the INFCE results and acceptance of the INFCE findings.

The INFCE findings supported by the ANS relating to safeguards include the following:

1. INFCE concluded that "Proliferation is primarly a political, and not a technical, matter" and that international measures already exist to reduce the risk of proliferation.

2. INFCE minimized concerns regarding the use of the commercial nuclear power fuel cycle as a route to proliferation. The evaluation stated, "The construction and planned misuse of fuel cycle facilities is not the easiest nor the most efficient route to acquire materials for the manufacture of nuclear weapons" and that, "The use of commercial grade plutonium is an unattractive route to the manufacture of nuclear weapons as compared with weapons grade plutonium produced by a dedicated program."

3. INFCE found with respect to fuel cycle services that, "means exist to minimize the danger of misuse of fuel cycle facilities - including technical measures, improved safeguards, and institutional arrangements."

4. Technical measures by themselves have only a limited ability to reduce proliferation risk. However, institutional arrangements were seen as contributing importantly to minimizing proliferation risks and to establishing assurance of supply.

5. INFCE concluded that improved safeguards can minimize proliferation. This view was expressed in the following observations:

"Further development and improvement of existing methods and techniques were foreseen as necessary to meet safeguards objectives at reasonable costs, in connection with technologies for uranium enrichment, industrial-scale reprocessing or irradiated fuel, and mixed oxide fabrication for LWRs or breeder reactors.

"For future reprocessing and mixed oxide fuel fabrication plants it will be essential to take full account of criteria for effective international safeguards."

The above testimony reflects the official position of the American Nuclear Society. It is, however, possible to add to these basic concepts by way of example and description. The discussion that follows, therefore, is not part of the official ANS position, but it is my belief that it is consistent with and illustrative of the general principles officially approved by our Society.

Non-proliferation objectives can be achieved through a combination of institutional arrangements, safeguards and technical measures. While the statements that follow emphasize safeguards and technical measures, institutional arrangements are particularly important and should not be deemphasized. The IAEA has under consideration a variety of initiatives. In addition, ideas such as the leasing of nuclear fuel could also contribute to non-proliferation objectives.

In order for the institutional systems to function effectively, however, it is essential that there be a credible safeguards system. The International Atomic Energy Agency has established a system of safeguards designed to assure that nuclear materials are being used only for civilian purposes. Supporting that program are measurement equipment and verification techniques.

During the past decade there has been a substantial effort worldwide in research and the development of new instrumentation and techniques for verifying the identification, location, and quantity of materials. As a result, there is now a need for extensive applications engineering, in consort with the operators of facilities, to assure practical application of the instrumentation in all countries. For instance, the proposed expanded tests at Barnwell could add significantly to our knowledge on the use of advanced safeguards technology. Further, there is a great need for the establishment and support of an infra-structure for the maintenance and repair of instrumentation. Of particular importance is the development of reliable sources for spare parts. Regardless of how effective an instrument may be, if it cannot be relied upon, if its repair is not simple with readily available spares, it will gain little acceptance by the inspectors and see little application.

There is a continuing need for miniaturization of equipment. Inspectors have commented that it is difficult to take into the field all the equipment which is available to them. If the function of the instrumentation can be incorporated into smaller, light weight, rugged containers without compromising the sensitivity and reliability of the instrumentation, it will obviously improve the acceptability and utilization of the equipment.

Proper training is also an important ingredient in the application of the techniques and equipment which have been developed. There needs to be more emphasis and attention devoted to training at the International Atomic Energy Agency, particularly under realistic circumstances. Inspectors need to be trained on the equipment in real environments under typical field conditions. There have been developed new training methodologies which the Agency should adapt to its programs. This is particularly important at the IAEA because of the high turnover of inspectors.

Typically, the assignment of an inspector to the IAEA is for a two year period with the possibility of an extension. It generally takes about a year for the inspector to become accustomed to his role as an inspector and he may not become fully efficient or effective in his role until he nears the end of his second year, at which time he is preparing to leave the Agency. The Agency should review its policy of short term appointments and explore the desirability of longer term appointments for inspectors.

Ideally, there should be established an academy for prospective inspectors to provide them with a good and common foundation with regard to the use of safeguards techniques and equipment. The curriculum should include frequent trips into the field to apply the knowledge imparted under realistic circumstances. Upon graduation from the academy, the prospective inspectors should be given an appointment of sufficient length that the investment by the IAEA can be reasonably amortized. An appointment of at least five years seems reasonable in order for the Agency to take full advantage of the training and experience that the inspectors gain.

Standard reference materials are needed for calibration of field and laboratory equipment, and to support quality control and quality assurance programs. Not only is there a need for standards development, but equally important is a need for a reliable supply program so that the standards can be used. In the past there has been an inadequate support for standards programs. Domestically, there have been occasions when the lack of a supply of standard reference materials has adversely affected the domestic safeguards program. Licensees have had to ask for waivers from the Nuclear Regulatory Commission of quality control requirements because standard reference materials were not available. Typical of the lack of support for standards programs is the UF_6 Artifact Standards program which is currently languishing for lack of financial support.

There is also a need for standardization in the manner in which data is generated, aggregated, and processed. Today there is a flood of data into the IAEA; but, because there are not adequate standards applicable to its generation, there is extreme difficulty in analyzing the data in a meaningful manner. Without standardization, comparisons can be meaningless and analyses can be misleading. Even under the common code of regulations of our domestic programs, there is a recognized need for standardization in the development of data and consistency in the analysis of that data. At the IAEA, standardization needs to start with the Facility Attachments*, and each facility needs to be encouraged to produce its data in a common, consistent format using standardized procedures.

The IAEA needs encouragement to further its surveillance and containment program. In support of that program, there is a need for the development of improved integrity and reliability including redundancy of surveillance devices such as cameras. Storage and retrieval of the information needs to be improved so that the information can be acquired in an easy and timely manner. Although effective security seals presently exist for many applications, a major effort is needed to develop a new generation of rugged and inexpensive seals which can reliably operate in hostile environments such as fuel assemblies in an operating reactor. Of utmost importance is simplicity of attachment and ease of verification.

*The Agreement between the IAEA and the owner of the facility to be inspected.

To discuss the needs of the safeguards program of the International Atomic Energy Agency is not to denigrate in any fashion the accomplishments of the Agency or to minimize the importance of its current activities. Establishment of the IAEA was a significant accomplishment in international relations. Moreover, the IAEA safeguards program is unique because it requires sovereign nations to open their nuclear facilities and records to international inspection, a concession which is unparalleled in history. That so many nations of the world have accepted reliance upon the Agency's safeguards program is indeed a noteworthy accomplishment.

Unfortunately, much of the inspector's activities and the results of inspections are cloaked in secrecy, a fact which undermines the credibility of the safeguards program. The IAEA Safeguards Program can provide a window on the utilization of nuclear materials in participating nations. Each nation should recognize that fact and should take advantage of that window to display its good intentions for the world to see. Consequently, we should be encouraging all nations to reassess their demands for secrecy with regard to the Agency's activities and to encourage an open record of those activities. At the same time, nations may have commercial information which they wish to protect. Therefore, progress toward application of safeguards in an effective manner at the perimeter of facilities is a desirable goal. Achievement of this goal may convince some nations to place under IAEA safeguards facilities which contain such information.

The improvements to the IAEA program described above will enhance the IAEA ability to detect diversion or changes in normal operation. As such they constitute a restraint to the civilian nuclear power program being a source of nuclear weapons material. In addition to the safeguards system and their effective implementation, it has been suggested that non-proliferation objectives could be further achieved through research concerning technical measures, such as supplying fresh fuel in a "denatured" fashion so that diversion is further discouraged. This was the purpose of the CIVEX proposal made several years ago.

Another concern is in a "twilight zone" between institutional and technical arrangements. This involves the issues associated with resource accumulation of "dual use" materials. These are areas where useful research and analysis could further contribute to non-proliferation objectives.

Supplier nations have cooperated to a substantial degree in identifying items which should be subject to export controls. To date, however, the lists of restricted items have generally included only those materials, components or technologies which are clearly intended for use in sensitive nuclear facilities. In recent years much attention has been given to presumed efforts by some nations to import uncontrolled items which, in addition to their normal innocuous uses, can also have use in enrichment or reprocessing plants.

Some of these "dual use" items are so common that it would be virtually impossible to subject them to meaningful control. This may not be true of all, however, and supplier nations should make a determined effort to identify those commodities which have a clear application in sensitive nuclear facilities and for which controls may be feasible. Failure to make this effort would leave the supplier nations open to the criticism that they have turned a blind eye to an important proliferation problem.

A combination of improved safeguards and effective implementation, attention to technical constraints and institutional arrangements can assure that peaceful nuclear uses do not contribute to nuclear weapons. This means that programs must be conducted so that the risks associated with peaceful uses, whether they be risks to health, safety and the environment, or risks related to weapons proliferation, are contained at very low levels and perceived by the public to be acceptable.

Even with technical solutions, safeguards controls and institutional arrangements, a fundamental point that must be kept in mind is that the most important step to peace and stability throughout the world is to remove the motivation for war. One such possible motivation stems from the fact that nature did not distribute oil, gas, coal or uranium evenly around the world. Most nations do not have sufficient energy sources of their own. One of the ways to remove this motivation for war is to have assured supplies of energy. Nuclear power, rather than being a contributor to war, will help to achieve peace through providing energy to resource deficient countries.

A good bargain has been reached in the world between nuclear weapons and non-weapons nations, namely, that nuclear weapons are to be controlled and reduced while nations receive peaceful nuclear benefits. It is the renowned concept of "swords into plowshares". In addition, peaceful nuclear benefits can help remove one of the motivations for war and be a force for nuclear weapons control. The anti-nuclear weapons forces should be in the forefront of those advocating peaceful nuclear uses and the supporters of peaceful uses should support controls and reductions of nuclear arsenals.

ANS Document PPS-10
September 1981

UNITED STATES POST-INTERNATIONAL NUCLEAR FUEL CYCLE EVALUATION (INFCE) POLICY

A Policy Statement of the American Nuclear Society

The American Nuclear Society, founded in 1954, is a not-for-profit scientific and educational society of 13,000 scientists, engineers, and educators from universities, government and private laboratories, and industry.

Public Policy Statements are the considered opinions and judgments of the Society in matters related to nuclear science and technology. They are intended to provide an objective basis for weighing the facts in reaching decisions on important national issues.

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INTRODUCTION

In April 1977, the United States Government formally reversed its long-standing encouragement of commercial nuclear fuel reprocessing [giving as the reasons for this reversal of policy] the potential enhancement of non-proliferation of nuclear weapons and concern for the buildup of plutonium stockpiles. It decided to "defer indefinitely" commercial reprocessing and recycling of plutonium produced in the United States nuclear power program and to "restructure" and "defer" the United States breeder reactor program. That White House statement by the President on nuclear power policy also proposed an international review program which was convened in October 1977 as the International Nuclear Fuel Cycle Evaluation (INFCE) with more than sixty attending nations and organizations.

With the completion of the two-and-one-half year INFCE studies that the United States initiated, the pause to consider systematically the principal options that might be most supportive to non-proliferation objectives has been accomplished. Based on the INFCE conclusions, the American Nuclear Society (ANS) believes it is now appropriate and timely for the United States Government to revise its nuclear policy from that of indefinite deferral of reprocessing and of breeder development to a position of international leadership, emphasizing a balanced and appropriately paced program that permits light water reactor (LWR) fuel reprocessing, recycle and breeder development, including its fuel cycle, under effective safeguards.

This policy would reflect INFCE findings which included United States technical inputs and the carefully constructed technical and national judgments of the sixty-six participating nations and five international organizations. This action will not only demonstrate to foreign nations a United States appreciation of their need for energy assurance, but will also provide renewed leadership in the drive for assured energy supply, as expressed at the 1980 Venice Summit.

IMPORTANCE OF INFCE

Certain United States expectations for the study were realized. In particular and of great importance to continued international nuclear cooperation as envisaged by the Non-Proliferation Treaty was the demonstration that complex and potentially divisive issues can be dealt with constructively in a forum with both industrialized supplier countries and the user countries participating. This cooperation is required to establish systems and technologies that can effectively minimize the risk of proliferation while assuring energy supplies to all nations. Secondly, the serious United States concern about proliferation has been underscored with the international community and accepted as a vital issue, along with world concern about assurance of fuel supplies. By accepting and implementing the findings of the combined efforts and recommendations of sixty-six nations, the United States will demonstrate a willingness to again cooperate in a positive manner on international nuclear and energy concepts, and the United States will regain its leadership in influencing nuclear developments. In the world energy arena, this action by the United States would aid in avoiding major confrontations over Middle East oil through recognition of our ability, as a consumer of a major portion of the world's oil supply, to substitute alternative energy sources for diminishing oil supplies. This action would enable the United States to:

1. In United States diplomacy, use two powerful instruments of policy formation and policy execution: technical expertise and management skill.
2. Influence the direction and implementation of non-proliferation actions through continued international safeguards activities and institutional fuel cycle and breeder arrangements.
3. Remove a major hurdle in the domestic power debate regarding the present and future use of nuclear power.
4. Support the Western Alliance in reducing dependence upon oil.

INFCE FINDINGS

The final report of the INFCE program was issued at the end of February 1980, and some of the important findings are as follows:

1. Nuclear energy is expected to increase its role in meeting the world's energy needs and can and should be widely available to that end.
2. Proliferation is primarily a political, rather than technical, matter, and effective measures can and should be taken to minimize the danger of proliferation of nuclear weapons without jeopardizing energy supplies or the development of nuclear energy for peaceful purposes.
3. Assurance of supply and assurance of non-proliferation are complementary.
4. The use of nuclear power is considered to be necessary to provide a viable electricity supply option in a number of developing countries, as well as in developed countries.
5. The construction and planned misuse of nuclear power fuel cycle facilities is not the easiest or the most efficient route to acquire materials for the manufacture of nuclear weapons.
6. Alternative nuclear fuel cycles do not provide significant proliferation resistance and cannot be available until after the year 2000.
7. International safeguards are an essential feature of the nuclear power industry and must be an integral part of reprocessing, fuel fabrication, and the plants themselves from the inception of plant design.
8. The uranium/plutonium (U/Pu) fuel cycle is optimal from an energy efficient point of view, and the diversion risks encountered in the various stages of the fast breeder reactor (FBR) fuel cycle present no greater difficulties than in the case of the LWR with the U/Pu cycle, or even in the case of the once-through cycle, in the long term.
9. Waste management methods, including spent fuel storage, have, for the most part, been proven operational or demonstrated on an engineering scale; no major technical problems remain to be resolved.
10. Institutional arrangements were seen as important to minimizing proliferation risks and to increasing assurance of supply. Multinational and international fuel cycle centers are attractive non-proliferation institutions, and their formation should be encouraged.
11. Deployment of a significant number of fast breeder reactors (FBRs), using current technology and oxide fuels, would be feasible by 2000.

These findings are consistent with the United States nuclear technical community, which expressed almost identical judgments in 1977 and 1978 through committees such as the Liquid Metal Fast Breeder Reactor (LMFBR) Review Steering Committee and in National Academy of Science evaluations.

The basic technology for reprocessing, plutonium handling, and thermal recycle is well established and widely disseminated. At least nine nations have reprocessed spent fuel, and several have plans to expand their programs. At least 25 metric tonnes (MT) of separated plutonium exist today, and as much as 150 MT may, irrespective of the U.S. policy, exist by the end of this century.

Although some nations consider recycle in LWRs to be only marginally cost effective, reprocessing and recycle are (a) indispensable to a breeder fuel cycle, and (b) seen by some countries as a positive near-term contribution to their energy independence. The matter is emphasized by the conclusion that uranium savings to 35 to 40% would be achievable from thermal reactor recycle, compared with the once-through cycle for LWRs.

RECOMMENDATIONS FOR A REVISED UNITED STATES POLICY

It is clear from the INFCE findings, supported by the results of the domestic Non-Proliferation Alternative Systems Assessment Program (NASAP), that there is now both a national and international consensus that endorses the U/Pu fuel cycle and the breeder, and defines the directions in which to proceed on development and demonstration. Therefore, ANS recommends the adoption of a revised United States nuclear policy, which includes proceeding with a balanced and appropriately paced program of reprocessing and recycle and with the development and demonstration of the breeder and its fuel cycle. Specifically, the ANS recommends that:

1. The Government, with its agencies, endorse nuclear power and that such endorsement provide the utilities and United States industry with a stable and predictable licensing, financial, safety and safeguards environment.
2. The Administration issue a policy statement on reprocessing and recycle (or fuel reuse) that acknowledges INFCE findings and which proceeds with those actions–Generic Environmental Statement on Mixed Oxide Fuel (GESMO) and licensing–which would lead to construction and operation of such facilities.
3. The Administration endorse a high-confidence strategy to proceed with breeder system development and commit itself to the prompt construction of a fast breeder reactor demonstration plant.
4. The Administration take the steps needed to define its program for improving internationally acceptable safeguards and demonstrating application and surveillance of such safeguards through the International Atomic Energy Agency (IAEA).
5. The United States Government, in close cooperation with the nuclear industry, take the initiative in establishing regional, international, or multinational institutional solutions for sensitive fuel cycle services that would provide supply assurance to all nations at reasonable cost for such services.
6. The Administration and Congress re-establish the United States as a reliable nuclear supplier by reviewing the Nuclear Non-Proliferation Act of 1978 and other laws, rules and regulations for needed modifications to reflect INFCE's recommendations for a proliferation resistant worldwide nuclear regime.

DISCUSSION OF THE IMPLEMENTATION OF INFCE FINDINGS THROUGH A REVISED UNITED STATES POLICY

The relationship of this recommended policy to INFCE findings is described as follows:

I. *Stable and Predictable Nuclear Power Environment*

The use of nuclear power is expanding worldwide in both industrialized and less developed countries. Current practice in other nations was stated in INFCE to be, "well adapted to meeting the needs of suppliers and consumers, and it seems likely that it will continue to do so." To retain this stability, both here and abroad, there is an acknowledged need to stabilize, shorten, and prevent nonproductive disruptions of the licensing and environmental assessment process. By providing, through a realistic approach, a practical example that achieves the goals for environmental concern and safety, the United States can better ensure adoption of similar procedures tailored to the needs of each country.

II. *LWR Recycle*

Because of the wide range of estimates for worldwide uranium supply, the need for improved LWRs and LWR recycle to extend this finite resource was addressed in INFCE. Working Group 4, reviewing reprocessing, plutonium handling, and recycle, concluded that the "basic technology is well established" with little adverse environmental impact. As to economics, it was concluded that "no one fuel cycle can be said to have a clear economic advantage in all cases." Therefore, many nations may choose to proceed with LWR recycle for a variety of reasons related to their particular overall situation, with economics being only one factor.

The potential savings from recycle in uranium over the once-through cycle were found by INFCE to be 35 to 40%, and even with improved once-through LWRs, optimized plutonium recycle would achieve uranium savings of 20 to 30%. This conservation of uranium, a depletable world resource, and the fact that operating experience and an established industry infrastructure from LWR recycle is ultimately needed for the breeder system makes the resumption of recycle demonstration a necessary United States initiative. With recycle, the United States can help the world uranium supply situation, particularly after the year 2000, and permit the smaller, less developed countries to obtain uranium supplies for LWRs at reasonable prices. The operation of industrial-scale reprocessing and refabrication facilities will also reduce the uncertainties of recycle costs. These results, made available to the international nuclear community, would assist our reinstatement of a leadership position in nuclear power technology.

III. *The Breeder*

The choice of the uranium/plutonium system for light-water reactors and breeders was confirmed as the best choice by INFCE studies. Similarly, INFCE determined that the need for world energy sources, free from supply restrictions, makes early adoption of the breeder in developed, industrialized countries, a prudent course to follow.

A vigorous United States breeder program, possibly in conjunction with other nations, would meet the need expressed by INFCE as follows:

> "If nuclear capacity growth approaches INFCE's high projection, substantial deployment of improved thermal reactors and fast breeder reactors early after 2000 would be required to provide assured nuclear electricity supply."

The inherent ambiguity of the present United States position regarding recycle and the breeder, as they pertain to uranium use and availability of indigenous energy sources, would thus be avoided by a change in the United States breeder program to a high confidence strategy, permitting early deployment of breeders. Prudent energy supply planning suggests the importance of erring on the side of supply in excess of sufficient future and available energy resources, rather than a gamble against undersupply and the risk of shortfalls.

Even for lower nuclear capacity projections, proceeding with plans for early deployment of the breeder represents a prudent course of action should the need for more power occur, or if coal and solar goals are not attained. Both INFCE and NASAP point to the long development and demonstration time needed for the breeder system, which even in a vigorous program, may not permit United States deployment until 2010 or later.

The NASAP report also succinctly summarizes the need for an effective United States breeder program as follows:

> "In order to influence the liquid-metal fast breeder reactors programs of other countries, not only must the U.S. be a member of the fast-breeder development community, but it also needs to exercise leadership in developing the technical measures which would reduce the proliferation risk of fast breeder reactors. In particular, how to design reprocessing and recycle plants to facilitate international safeguards and improve proliferation resistance should continue to be investigated to understand their proliferation-resistance effects better, as well as to establish their technical and economic tradeoffs."

A high confidence, aggressive breeder program, integrating all elements necessary for a breeder power economy, such as reactors, reprocessing, and fuel fabrication, should be initiated. Research and development (R&D) and demonstration plants must be identified and planned with established budgets and firm commitments to ensure that the United States option for early deployment of breeders is not lost. As important is the necessity to develop a breeder industry infrastructure and skills.

IV. *Reprocessing and Safeguards*

INFCE sees reprocessing as a necessary preliminary to many fuel cycles and as an essential one for the breeder. It was observed that the proliferation risk for recycle plants is manageable and could be further minimized by proper application of advanced safeguards, international surveillance, technical modifications, and through services provided by international or multinational institutional facilities. The United States concern over proliferation from reprocessing and the U/Pu system was specifically addressed by INFCE as follows:

1. INFCE concluded that "Proliferation is primarily a political, and not a technical, matter" and that international measures already exist to reduce the risk of proliferation.
2. INFCE minimized concerns regarding the use of the commercial nuclear power fuel cycle as a route to proliferation. The evaluation stated, "The construction and planned misuse of fuel cycle facilities is not the easiest nor the most efficient route to acquire materials for the manufacture of nuclear weapons" and that, "The use of commercial grade plutonium is an unattractive route to the manufacture of nuclear weapons as compared with weapons grade plutonium produced by a dedicated program."
3. INFCE found with respect to fuel cycle services that, "means exist to minimize the danger of misuse of fuel cycle facilities–including technical measures, improved safeguards, and institutional arrangements."
4. Technical measures by themselves have only a limited ability to reduce proliferation risk. However, institutional arrangements were seen as contributing importantly to minimizing proliferation risks and to establishing assurance of supply.
5. INFCE concluded that improved safeguards can minimize proliferation. This view was expressed in the following observations:

> "Further development and improvement of existing methods and techniques were foreseen as necessary to meet safeguards objectives at reasonable costs, in connection with technologies for uranium enrichment, industrial-scale reprocessing or irradiated fuel, and mixed oxide fabrication for LWRs or breeder reactors.
>
> "For future reprocessing and mixed oxide fuel fabrication plants it will be essential to take full account of criteria for effective international safeguards."

As noted before, the United States must regain its nuclear leadership in the world. By the demonstration of reprocessing and recycle, using improved safeguards and subjecting these demonstrations to IAEA surveillance, the United States would not only provide meaningful data to the international community, but would necessarily address the issue of nuclear waste management. As noted by INFCE, the management of low and medium level wastes has been demonstrated and "well proved" (and) "The vitrification technology for immobilization of high level wastes is currently being applied on an industrial scale for wastes from low burn-up fuels. This technology has been demonstrated on an engineering scale for wastes from high burn-up fuel. The reference technology for deep underground repositories for high level wastes is based on generic concepts and field experience. Some of the assumptions made can be validated only if the repositories of the kind considered were actually to be constructed and operated."

V. *Establishing Multinational Institutional Services and Verification Programs for Safeguards*

INFCE noted the "growing importance of international cooperation through the development of recommendations, guidelines and codes of practice" for an effective, worldwide, proliferation-resistant nuclear industry. The evaluation also observed that institutional arrangements were seen as contributing importantly to minimizing proliferation risks and establishing assurance of supply. The United States policy should address these observations by encouraging multinational services, such as fuel supply assurance, plutonium storage, and spent fuel storage concepts now under discussion, and also by establishing a multinational fuel cycle center.

The Carter Administration policy of deferring reprocessing has hampered research and development efforts to improve safeguards technology. The United States, with more than twenty years of commercial and national laboratory involvement with safeguards, should be taking the lead in this essential international activity.

VI. *Assurance of Supply*

A revision in United States policy should take into account the following INFCE findings:

> "The main concerns with respect to assurance of supply have arisen not from commercial defaults or market failure, but as a result of government intervention in pursuit of national policies and objectives.
>
> "The right of prior consent should be exercised in a manner that is predictable and that conforms to any understanding that may have been reached between the parties when the right of prior consent was estabiished."

The revised United States policy must consider the needs and sensitivities of both industrialized and lesser developed countries. A return to many of the precepts of the U.S.-initiated Atoms for Peace concept would do much in this direction. It would meet the INFCE observation on the "effectiveness and acceptability of bilateral agreements between developing and industrialized countries" wherein criteria would include:

1. Responsiveness to needs
2. Effective safeguards
3. The extent to which non-proliferation undertakings, which would have to be mutually agreed to, would interface with or limit the peaceful nuclear power program of a country.

Also to be considered are international arrangements, which may cover the following areas:

1. International arrangements for assured fuel and heavy water supplies.
2. Participation in specific nuclear fuel cycle activities on a bilateral or multilateral basis, consistent with the non-proliferation commitments of the parties involved.
3. Increased availability of specialized training programs for developing the required manpower of nuclear installations.
4. Increased availability of resources for nuclear power programs from international financial organizations.

The impact of the United States action on international nuclear activities in the Nuclear Non-Proliferation Act of 1978 (NNPA) has created a counterproductive effect because many nations now believe that the United States will follow a path most advantageous to its own interests, using leverage in nuclear supplies. Restrictions in nuclear supply are evident from the Act's provisions:

1. Unilateral United States demand that all bilateral Agreements for Cooperation be renegotiated or United States nuclear exports to that country will be suspended.
2. Requirements for United States consent to retransfers of special nuclear material produced through the use of United States supplied facilities.
3. Requirement for United States prior approval for reprocessing of material used in or produced through the use of United States supplied facilities.
4. Requirement for United States approval in advance of facilities in which United States-supplied material, or material used in a United States-supplied facility, will be stored.

The ANS urges that the impact of the NNPA on foreign relations and United States industry be examined promptly so a positive, helpful, yet responsible role would accrue to the United States in world energy councils.

CONCLUSIONS

From a detailed review of the INFCE results and the implications with respect of a revised policy for the United States nuclear policy and actions, ANS concludes as follows:

1. The previously expressed concern regarding proliferation can now be achieved with international cooperation on safeguards and the development of appropriate institutional arrangements through the leadership of the United States.
2. The United States should take a necessary step to restore the domestic nuclear option by accepting and implementing the findings of INFCE. Steps should be taken to implement the recommendations in this position paper on the U/Pu cycle, reprocessing and the breeder.
3. The Government should also take the actions recommended to restore credibility and leadership in international nuclear policy as a reliable supplier and in safeguards development by (a) signaling attention to the INFCE results, (b) acceptance of the INFCE findings, and (c) taking the legislative steps necessary to revise the Nuclear Non-Proliferation Act.

Mrs. BOUQUARD. Thank you very much, Mr. Muntzing, for your very valuable testimony.

Mrs. BOUQUARD. I made the statement yesterday in my testimony before the House Committee on Foreign Affairs that the way to reduce proliferation is to reduce the desire for nuclear weapons. I certainly concur with your statement that by providing developing nations with the technology for the peaceful use of nuclear power, we will deter their desire for weapons.

You were talking about the need for an academy for the IAEA inspectors, the present 2-year assignment schedule, and some of the problems associated with it. Do these inspectors specialize in certain types of facilities or do they rotate? Are they specialty inspectors?

Mr. MUNTZING. Yes, the inspectors tend to be somewhat specialized and certainly, as Dr. Kouts pointed out earlier today, there is a significant difference between inspecting a light water reactor facility and inspecting a reprocessing facility. The fact that you have separated plutonium in the latter is indeed a significant point, so that you do have different instrumentation and different requirements and different specializations.

As a matter of fact, as we look ahead it is not the light water reactors and their inspections which are major problems. We should continue to do that. We do not want to see people adding unauthorized fuel rods to a light water reactor. However, the more important area where we must be concerned involves fuel cycle facilities such as enrichment facilities and the reprocessing facilities. There we need the augmented inspection efforts, the augmented instrumentation, the augmented programs that integrate not only safeguards accountancy but physical security as well. Other concepts such as multinational efforts provide another layer of proliferation control because you have many nations as part owners and operators, and that in itself contributes to greater proliferation controls. Therefore, there is a distinction between the different types of facilities and what you need in one will differ compared to another.

Mrs. BOUQUARD. Do most of the inspectors have a technical background and education?

Mr. MUNTZING. Yes, Madam Chairman, I can say that they do.

Mrs. BOUQUARD. In view of your long experience with the IAEA, are you optimistic or pessimistic about its ability to maintain widespread confidence in international safeguards? Do you think there has been a deterioration in the performance of the organization? What is your overview?

Mr. MUNTZING. The International Atomic Energy Agency has had an outstanding record since its inception 20 years or more ago, and I think it is fair to say that for the facilities covered by IAEA safeguards that they have been quite effective. Recently they have had to condition some of their statements because of concerns that the Agency has seen in certain countries but to date the safeguards have been effective.

Now as we look to the future, this outstanding record that has been achieved in itself is a problem because you get a certain amount of complacency may creep into the system. The safety record of nuclear powerplants is an analogous example, where the record is good.

Mrs. BOUQUARD. I was getting ready to ask you if you thought they might be getting too complacent about safeguards.

Mr. MUNTZING. This is a fear but in fact these hearings help to focus on safeguards. If this committee can encourage an attitude so that complacency is avoided that would be a very fine contribution to make.

As we look at the IAEA, the efforts in this country to develop technology, and the support by the United States to the IAEA can help to remove whatever complacency exists if in fact the attitudes are good. The equipment is there and we need to use it. Standards need to be implemented. The inspectors need to be trained and we need more inspectors. We need to design facilities right from the very beginning to achieve safeguard objectives.

With these things, we are able to say to ourselves and to the public that there is confidence that we can have the benefits of peaceful nuclear uses without diversion to unauthorized purposes. The IAEA is a cornerstone to that shipment and its new leadership under Director General Hans Blix seems encouraging . We here must give the IAEA very strong support and if we do then we can be confident that it will succeed.

Mrs. BOUQUARD. It seems to me the overriding thread in all of the testimony today has been a need for greater inspector training. I think there is a broad consensus on that.

We know that the IAEA does verification. Do you feel that they lean too heavily on surveillance techniques or do you think there is a good balance between surveillance and materials accounting procedures and technology?

Mr. MUNTZING. There are a lot of good techniques that have been developed by our national laboratories as well as by private industry, such as at Barnwell. The IAEA could be more aggressive in using the new devices because through the years they have tended to rely a lot on human inspectors. It is now time to try to move that emphasis from the human factor more to the hardware factor. In fact, with such programs as the RECOVER program and other programs through computer-advanced technology and satellites, you achieve virtually real-time information on operations. This is a excellent use of technology and hardware.

You may have a resident inspector in the sensitive facilities, which would be good, but still you have the human factor. It is time to continue to use inspectors and to train them well but to emphasize and use the technology which has been developed recently and which now is available. I would feel better if we shifted the emphasis more to hardware and less to the human factor. Both are essential—let me say that—both are essential but I think the emphasis could be changed.

Mrs. BOUQUARD. My next question is somewhat beyond the given agenda, but I am going to ask it anyway. As I stated earlier, yesterday I testified before the House Committee on Foreign Affairs concerning changes in the Nuclear Non-Proliferation Act of 1978. Would you give me your assessment of the effectiveness of the NNPA in general and what changes you would recommend?

Mr. MUNTZING. The Nuclear Non-Proliferation Act has created various problems. It has cast doubt on the United States being a reliable supplier of nuclear fuel and technology. At the same time, it has emphasized some things which are important to emphasize, such as the use of safeguards, and so it has its proponents and its detractors.

My personal opinion is that it would be inappropriate at this time to go forward with major amendments to the act. The reason is, that there are still things underway that the act calls for, such as renegotiation of agreements for cooperation which have not been concluded. If the Congress continues to change the ground rules as represented by the Nuclear Non-Proliferation Act this worsens our position as a reliable supplier. What we need is stability, and if in fact we believe that certain changes are necessary in the international regime with regard to nonproliferation, it should be done in consultation with the principal nuclear nations of the world. We can do it through the IAEA; we can do it through the OECD and the Nuclear Energy Agency; we can do it in an ad hoc organization such as the suppliers' committee.

I personally think that when a change is appropriate in the international arena with regard to nonproliferation, that the principal suppliers and users together should develop the programs. For instance, the IAEA is working in such areas as international plutonium storage and assurance of fuel supply. Until those initiatives underway at this time in the international arena are concluded, it would be inappropriate to modify the Nuclear Non-Proliferation Act. We should not unilaterally, as one country, proceed to set the ground rules. The day when we could do that is past, and other nations now are able to supply nuclear fuels and technology.

All that will happen if we continue to tinker with the ground rules is to drive more and more people away from us, to erode our leadership abilities, and to isolate the United States. It will mean that our influence over nonproliferation matters will be reduced. Therefore, I would not change the law now. It should be done only after international consultation.

For instance, a good example of a way to proceed is the Physical Protection Convention which the IAEA, under urging from the United States, produced. The United States has signed it. Other nations are in the process of signing it and it will take various domestic laws to implement it. This is the way to proceed in this area, namely, to develop an international convention where the principal suppliers and users are agreed and then let the national laws that need to be enacted underneath the international umbrella be enacted. That is my basic position with regard to the Nuclear Non-Proliferation Act. I do happen to have a list of items that I would change if I were rewriting it but I would not do it now.

Mrs. BOUQUARD. I certainly appreciate your perspective on the effectiveness and changing of the ground rules. I think you would agree with me that case-by-case approval of shipment of nuclear materials certainly could do with some modification.

Mr. MUNTZING. Yes, I would agree with that. That is a change that I would make.

Mrs. BOUQUARD. Well, thank you so very much for your testimony. With our last panel and with you also, Mr. Muntzing, I would like to ask permission for members of this committee to submit additional questions for the record. I may think of one or two that I would like to have included in the record of today's hearing as well as yesterday's.

I want to thank all of you that have participated in these very enlightening hearings. I think that much good has been accomplished and I hope that you who have participated share my enthusiasm about what we have done in the last 2 days. We look forward to your continued cooperation and the value of your expertise.

Thank you so very much. The subcommittee now stands adjourned.

[Whereupon, at 12:15 p.m., the subcommittee recessed to reconvene at the call of the Chair.]

[The following was received for the record:]

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MINORITY STAFF DIRECTOR

August 13, 1982

Dr. Herbert J.C. Kouts, Chairman
Department of Nuclear Engineering
Brookhaven National Laboratory
Upton, Long Island, NY 11973

Dear Dr. Kouts:

We appreciated having you testify on the Brookhaven National Laboratory's safeguards research and development programs at the Subcommittee's hearing on August 4, 1982. Chairman Bouquard would like to supplement the record of the hearing with some additional questions regarding the programs. We appreciate your cooperation on this matter and we hope that this information can be provided by September 7, 1982.

If you have any general questions regarding these requests, please contact me at 202/225-8056. If you have any questions regarding the specifics, please contact Dr. Harlan Watson of the Subcommittee staff at 202/225-3472.

Sincerely,

John V Dugan Jr./jws
JOHN V. DUGAN, JR., Staff Director
Subcommittee on Energy Research
and Production

JVD:Wjs
Enclosures

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
CHAIRMAN BOUQUARD'S QUESTIONS ON
TECHNICAL ASPECTS OF NUCLEAR NONPROLIFERATION: SAFEGUARDS
Hearing held August 4, 1982

1. What thought is being given to implications of improved equipment for the future recruitment and training of IAEA inspectors?

2. Exactly who has the lead responsibility for safeguards R&D, and do the various coordinating groups have any authority other than to try to reach a consensus?

3. If you had it within your power and authority to devise a different scheme or organizational format for conducting domestic and international safeguards research and development, how would you change the current set-up?

bnl
aui

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.

Upton, Long Island, New York 11973

Department of Nuclear Energy

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FTS 666

August 19, 1982

Dr. John V. Dugan, Jr.
Staff Director
Subcommittee on Energy Research
and Production
Committee on Science and Technology
U.S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, D.C. 20515

Dear Dr. Dugan:

Attached are replies to the questions you sent me in your letter of August 13, 1982, to supplement the record of the subcommittee hearing on nuclear materials safeguards programs.

Sincerely,

Herbert Kouts

Herbert Kouts
Chairman

Attachment

HK:ns

1. What thought is being given to implications of improved equipment for the future recruitment and training of IAEA inspectors?

   Both ACDA and DOE (and its predecessors) have been helping IAEA in technical aspects of safeguards ever since the IAEA first assumed this responsibility. This long-standing relationship has led to excellent understanding of the abilities and limitations of members of the IAEA's safeguards inspection staff. A great deal of attention is concentrated on the need to design equipment that can be readily and competently used by IAEA inspectors. This equipment does not grow more complex with time, because simplicity and ease of operation are always required. In addition, the training courses at LASL in non-destructive analytical methods familiarize new inspectors with the equipment they will be using.

2. Exactly who has the lead responsibility for safeguards R&D, and do the various coordinating groups have any authority other than to try to reach a consensus?

   DOE is responsible for the R&D it sponsors, which is principally directed at domestic safeguards, but is partly for international application. DOE is also responsible for management of the POTAS program. Responsibility for the content of the POTAS program rests with the Technical Support Coordinating Committee, chaired by the Department of State. In this Committee, the decisions are generally made by consensus, though this consensus sometimes reflects any overriding interests and responsibilities of the Department of State.

   Other coordinating groups, such as the semi-annual meeting of representatives of IAEA and U.S. to review the POTAS program, and the regular meetings of program coordinators from the DOE laboratories, work essentially by consensus. Presumably this will also be true of future coordination meetings among representatives of the countries having programs in safeguards assistance to IAEA.

3. If you had it within your power and authority to devise a different scheme or organizational format for conducting domestic and international safeguards research and development, how would you change the current set-up?

   In most respects I would not introduce changes. Programs are progressing well, with good rapport among the various authorities and contributors in this country. I can think of one addition that would be beneficial.

   There is some lack of central formal thinking and planning of safeguards research needed for international application. The POTAS program does very well in responding to needs ascertained by IAEA and requested by that body, and it even provides some research that has been identified through U.S. input. But it does not have any broad responsibility to foresee future IAEA needs and problems and to prepare for them. The DOE and ACDA research programs are not generated in response to any centralized and formalized process; each agency follows its own wisdom. I think it would be useful to have a standing body generating a governmental view on future needs, which can be fed into DOE and ACDA programs. Such a body could logically report to the National Security Council or to the President's Science Advisor. One possibility is an advisory group formed through the National Academy of Engineering, an arrangement which would give continuity.

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MINORITY STAFF DIRECTOR

August 16, 1982

Dr. William C. Myre
Director of Nuclear Security
  Systems
Sandia National Laboratories
Organization 9200
Albuquerque, NM 87185

Dear Dr. Myre:

We appreciated having you testify on the Sandia National Laboratories' safeguards research and development programs at the Subcommittee's hearing on August 4, 1982. Chairman Bouquard would like to supplement the record of the hearing with some additional questions regarding the programs. We appreciate your cooperation on this matter and we hope that this information can be provided by September 7, 1982.

If you have any general questions regarding these requests, please contact me at 202/225-8056. If you have any questions regarding the specifics, please contact Dr. Harlan Watson of the Subcommittee staff at 202/225-3472.

Sincerely,

John V. Dugan Jr. /jws

JOHN V. DUGAN, Staff Director
Subcommittee on Energy Research
  and Production

JVD:Wjs
Enclosures

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
CHAIRMAN BOUQUARD'S QUESTIONS ON
TECHNICAL ASPECTS OF NUCLEAR NONPROLIFERATION: SAFEGUARDS

1. It was noted that Sandia has developed for the NRC computerized analysis programs such as the Safeguards Automated Facility Evaluation, the Safeguards Network Analysis Procedure, and the Estimate of Adversary Sequence Interruption techniques. Would you please elaborate on what each of these programs does? Do they have any application in the international arena?

2. What is the scope of the ongoing Hexapartite Safeguards Project? Is it narrowly focused on centrifuge enrichment technology or is it also examining other enrichment technologies? In particular, is it considering any of the advanced isotope separation technologies?

3. Was Sandia involved with the preparation of the IAEA guidelines for the physical protection of nuclear materials and facilities?

4. What access does the IAEA have to the work that Sandia does for the NRC and other government clients?

5. Presumably, the physical protection and security system programs presume adversaries. Does Sandia make its own assumption as to adversaries, or does it have to work from NRC and DOE assumptions?

6. To what extent does Sandia study the behavior of the terrorists as a basis for deciding what kind of threat a security system must defeat?

7. The testimony lists many separate research projects done in direct support for the IAEA, under POTAS, and under the DOE Initiative Program.

   a. Are all of these projects equally applicable to all nuclear fuel cycles?

   b. Are some more useful for LWR and HWR cycles than for plutonium fuel cycles?

   c. Are some specifically in support of advanced fuel cycles that would use plutonium, or for recycle in conventional reactors?

   d. How would the results of all of this R&D, assuming it is fully employed, affect public doubts about the adequacy of IAEA safeguards?

8. Only FY 1982 program funding was given. How does this compare to the FY 1981 and FY 1983 budget levels? What will Sandia be doing in FY 1983 in these areas?

9. How much, if at all, was IAEA involved in design of GCEP safeguards? Does France provide comparable information for its Eurodif gaseous diffusion plant?

10. Factor 2 listed in the direction of future R&D notes the need for much more work on safeguards for bulk-handling facilities, especially those handling plutonium.

    a. What targets should be set for this R&D?

    b. What changes in existing Federally funded programs would be necessary to hope to reach these targets?

    c. Where are the best places to get the work done?

11. If you had it within your power and authority to devise a different scheme or organizational format for conducting international and domestic safeguards research and development, how would you change the current set-up?

W. C. Myre, Director
Nuclear Security Systems

Sandia National Laboratories
Albuquerque, New Mexico 87185

September 3, 1982

Dr. John V. Dugan
Staff Director
Subcommittee on Energy Research
and Production
Committee on Science and Technology
U.S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, D.C. 20515

Dear Dr. Dugan:

Enclosed you will find my answers to the questions you asked in your letter of August 16. I have also included for your information copies of the Sandia documents referenced in the answer to the first question.

Sincerely,

WCM:dsa

Encs. A/S

QUESTIONS AND ANSWERS

RESULTING FROM THE
TESTIMONY BY W. C. MYRE
TO THE
SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
ON
TECHNICAL ASPECTS OF
NUCLEAR NON-PROLIFERATION: SAFEGUARDS

HEARING HELD AUGUST 4, 1982

Question 1

It was noted that Sandia has developed for the NRC computerized analysis programs such as the Safeguards Automated Facility Evaluation, the Safeguards Network Analysis Procedure, and the Estimate of Adversary Sequence Interruption techniques. Would you please elaborate on what each of these programs does? Do they have any application in the international arena?

Answer

The Safeguards Automated Facility Evaluation (SAFE) Method performs an overall evaluation of the physical protection system (PPS) at a facility. SAFE is based on a model of the facility which is a computer representation of the physical characteristics of the facility. The input to SAFE is highly automated. The analyst specifies performance measures for the PPS components such as delay time provided by barriers and the probability of detection for sensors along the adversary path. Critical adversary paths are found based on three measures: 1) minimum adversary time delay, 2) minimum probability of adversary detection, and 3) minimum probability of interruption (probability that adversaries can be detected with sufficient time remaining along their path for a security force to arrive). These critical adversary paths can be studied using the Estimate of Adversary Sequence Interruption (EASI) model. EASI performs a probabilistic analysis of interactions among basic PPS functions--detection, delay, communication, and response. The Brief Adversary Threat Loss Estimator (BATLE) model is used to provide an estimate of the probability that the security force can defeat the adversary. BATLE provides information such as number of combatants remaining at end of engagement, duration of engagement, and probability of either side winning the engagement.

The Safeguards Networks Analysis Procedures (SNAP) is a computer simulation language specifically developed for modeling safeguards systems. The analyst must construct models to represent the safeguards system (facility and security force) and to represent an adversary scenario. These models are constructed from symbols defined by SNAP to represent elements of the safeguards system (barriers, spaces, sensors, etc.) and the procedures and actions of the security force and adversary forces. The network models provide the input for analysis of the specific scenario.

EASI is a highly transportable model which runs on a hand-held calculator. Over 600 users manuals have been distributed domestically and internationally.

More detailed information concerning SAFE, SNAP, EASI, and other physical protection models is attached as SAND79-0428, SAND79-1372, SAND77-0082, SAND80-0352, and a Sandia Tech Note. These models have been applied to their physical protection systems by other countries. They are not directly applicable to IAEA safeguards since physical protection is the responsibility of each state.

Question 2

What is the scope of the ongoing Hexapartite Safeguards Project? Is it narrowly focused on centrifuge enrichment technology or is it also examining other enrichment technologies? In particular, is it considering any of the advanced isotope separation technologies?

Answer

The goal of the Hexapartite Safeguards Project (HSP), to quote from its charter, is to develop by fall of 1982 an "...adequate technical basis of technical experience and information which can be used by the IAEA, Euratom and the State involved in their evaluation of the various safeguards approaches and the possible development of arrangements for the direct implementation of an effective efficient safeguards system to specific facilities. The technical objective of the Project is to facilitate the application of effective and efficient international safeguards at uranium enrichment plants of the gas-centrifuge type; this is to be achieved through the exchange of relevant information, thereby coordinating individual development efforts, and by the technical consideration of possible safeguards approaches. The non-access case and other cases of varying degrees and frequency of access will be treated in parallel." As this quotation indicates, the HSP is focused on centrifuge enrichment technology. The participants are from countries that either operate, or plan to operate centrifuge plants, and from international safeguard agencies. To the best of our knowledge no HSP discussions have included advanced isotope separation technologies.

Question 3

Was Sandia involved with the preparation of the IAEA guidelines for the physical protection of nuclear materials and facilities?

Answer

IAEA guidelines for physical protection are contained in the basic document, INFCIRC/225, written in 1972. At that time Sandia was involved in IAEA safeguards only to the extent of developing certain hardware items, not related to physical protection, under the ACDA-sponsored program. Minor revisions were made to INFCIRC/225 in 1977, based in part on experimental work done at Sandia.

Question 4

What access does the IAEA have to the work that Sandia does for the NRC and other government clients?

Answer

Results of the safeguards and physical security work that Sandia does for the NRC and other non-DOE agencies are integrated into a comprehensive tecnnology and methodology base. Non-sensitive results from this work are available to the IAEA through several means: handbooks and reports, training courses, professional society meetings, and staff level exchanges. Handbooks and reports are shared with the IAEA when they are relevant to IAEA projects and, in some cases, when they report work specifically requested. For example, non-sensitive results of DOD funded intrusion detection developments are included in handbooks that the IAEA has access to. The International Training Course on Physical Protection which Sandia conducts for DOE under the provisions of the Nuclear Non-Proliferation Act is offered in cooperation with the IAEA. This course makes extensive use of NRC-sponsored evaluation methodologies. Active participation by Sandia staff in professional society meetings (e.g., American Nuclear Society, Institute of Nuclear Materials Management, etc.) provides another means of sharing results of non-DOE funded work with the IAEA. Staff exchanges include the loan of "cost-free experts" to the IAEA, sometimes for projects that take advantage of experience in non-DOE sponsored work.

Question 5

Presumably, the physical protection and security system programs presume adversaries. Does Sandia make its own assumption as to adversaries, or does it have to work from NRC and DOE assumptions?

Answer

Sandia has access to several sources of information on the threat to nuclear facilities, and sponsors research on the nature of the threat. This work supports the long-range application of safeguards R&D and provides, in part, a technical basis for DOE and NRC policy formulation in this area. In addition, Sandia shares in the results of threat investigations sponsored by the NRC, the DOD, the Department of Commerce, and other government organizations. Relevant data from the intelligence community is available through DOE interfaces with those agencies. Discussions with DOE headquarters and field security personnel provide current information on developments or trends on threats specific to DOE sites. The combination of these sources serves as a basis for setting R&D physical security goals and for anticipating long-term changes in the threat spectrum. For projects aimed at providing technical support for physical security upgrades at specific sites, the guidance and performance goals stipulated by DOE for the particular upgrade program are used.

Question 6

To what extent does Sandia study the behavior of the terrorists as a basis for deciding what kind of threat a security system must defeat?

Answer

The threat research referred to above characterizes potential adversaries in terms of capabilities or attributes, motivations, and modus operandi. An important category of potential adversaries is the terrorist category. The threat research, much of which has been carried out at the Rand Corporation under Sandia subcontracts, has examined a large data base of case histories of terrorist incidents to delineate past terrorist behavior. In addition, extrapolating on that case history and based on an analysis of terrorist motivations, the Rand researchers have projected those actions vis-a-vis nuclear facilities which are likely to have the greatest appeal for terrorists in the future. When appropriate, because of the life-cycle time scale of physical security systems, Sandia also evaluates system designs for their ability to withstand actions outside the range projected by the threat research.

Question 7

The testimony lists many separate research projects done in direct support for the IAEA, under POTAS, and under the DOE Initiative Program.

a. Are all of these projects equally applicable to all nuclear fuel cycles?

b. Are some more useful for LWR and HWR cycles than for plutonium fuel cycles?

c. Are some specifically in support of advanced fuel cycles that would use plutonium, or for recycle in conventional reactors?

d. How would the results of all of this R&D, assuming it is fully employed, affect public doubts about the adequacy of IAEA safeguards?

Answer

The Sandia R&D program in support of IAEA safeguards is concerned principally with containment and surveillance equipment and its integration into system concepts. Many of the equipment developments have general application, such as surveillance TV cameras and auxiliary equipment, general-purpose seals, tamper-resistant features, and portal monitors. Other equipment has specialized application, such as fuel assembly identification devices for LWR or other types of fuel assemblies, CANDU bundle counters, and monitors for enrichment plants. In general, work under POTAS (and the earlier direct-support program) to the extent that it is specialized, is directed at more immediate needs and hence, to reactors of the types currently under safeguards. Other work, mainly under the DOE Initiatives program, is centered on conceptual safeguards designs for bulk-handling facilities such as reprocessing and fabrication plants, that will involve plutonium cycles, and some specialized equipment tailored to specific functions in those plants. As plutonium-cycle plants become more widespread, and as specific needs become better defined, it is expected that specialized equipment for safeguarding them will receive a greater proportion of the effort.

Public doubts as to the adequacy of IAEA safeguards are to a considerable extent the result of inadequate understanding of the IAEA safeguards objective and how it differs from the domestic objective. Moreover, the public does not understand how the system operates and the role it plays in the larger context of the control of proliferation. Sandia's work is in the field of containment and surveillance and it is not clear that the public's perception of how that element contributes to the overall assurance provided by IAEA safeguards is sufficient to understand what the impact of Sandia's work may be. For those who have a better understanding than the public in general, the impact of Sandia's program should be reassuring.

Question 8

Only FY 1982 program funding was given. How does this compare to the FY 1981 and FY 1983 budget levels? What will Sandia be doing in FY 1983 in these areas?

Answer

Sandia International Safeguards program funding for Fiscal Years 1981 - 1983 is shown below:

		$M	
	FY 81	FY 82	FY 83 (Expected)
POTAS	.94	.54	.70
DOE	3.4	2.9	2.8

Question 9

How much, if at all, was IAEA involved in design of GCEP safeguards? Does France provide comparable information for its Eurodif gaseous diffusion plant?

Answer

The IAEA has not been actively involved in the US study of strategies and systems for GCEP safeguards. The study has, however, been developed by individuals who are familiar with IAEA safeguards practices. The IAEA will play a role through the Hexapartite project (see Question 2). If IAEA safeguards are applied to GCEP, a facility attachment will be negotiated with input from the study.

We have no information about the arrangements between France and the IAEA relative to the Eurodif Plant.

Question 10

Factor 2 listed in the direction of future R&D notes the need for much more work on safeguards for bulk-handling facilities, especially those handling plutonium.

a. What targets should be set for this R&D?

b. What changes in existing Federally funded programs would be necessary to hope to reach these targets?

c. Where are the best places to get the work done?

Answer

At the present time, bulk-material plants that are under IAEA safeguards are relatively small, and current safeguards measures provide adequate assurance against diversion. For the most part, safeguards have been applied to existing plants, or plants not designed specifically to accommodate safeguards. Much larger plants will be built over the next 10 to 20 years, and a principal objective of coordinated efforts in the US and other countries is to develop concepts wherein safeguards features are closely integrated with process designs and plant layouts, with particular emphasis on the verification functions of Agency inspectors. Such coordinated R&D efforts bring together plant designers, safeguards specialists in the area of material accounting and containment/surveillance from various countries, and the IAEA technical staff into a common effort. The target is to have integrated system concepts, and the equipment to implement them, available for incorporation into the designs for new, larger plants as they are built. Such concepts, for example, could influence the design of the new, larger reprocessing plant in Japan.

The R&D community and the IAEA are at an early stage on the learning curve with respect to large bulk facilities. Much of the present work is in the development of integrated system concepts. As the work progresses, needs for new equipment will emerge, leading to individual hardware-development programs with completion dates coordinated with specific applications and IAEA requirements. At the present, with the work mainly in the concept-development stage, the level of funding appears to be appropriate. As equipment needs become established and more specific targets identified, more funding may be justifiable.

Under the present arrangement, DOE/OSS administers the DOE Initiative program through national laboratories that concentrate on specialized technical areas; in the case of

Sandia, containment and surveillance. POTAS is managed through a project office at Brookhaven, which maintains direct liaison with the IAEA, and also draws on the national laboratories expertise. In both these programs the laboratories' work is done in close collaboration with industry, with an appreciable amount of subcontracting and with widespread contacts among suppliers of specialized, component equipment. Direct links for technical exchange between the labs and the IAEA have been established and have been particularly effective. We believe these arrangements, with oversight and allocation of resources by DOE/OSS or the Technical Support Coordination Committee, and technical direction in assigned areas by the laboratories, have been productive.

Question 11

If you had it within your power and authority to devise a different scheme or organizational format for conducting international and domestic safeguards research and development, how would you change the current set-up?

Answer

The present organizational structure has evolved logically in response to the complex and interactive nature of various activities under the general heading of safeguards and physical protection. It has demonstrated the necessary flexibility to deal with changing circumstances, and we expect that it will continue to be responsive to new situations. Therefore, we see no need for a major, deliberate restructuring.

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USER'S GUIDE FOR EVALUATING PHYSICAL SECURITY CAPABILITIES OF NUCLEAR FACILITIES BY THE EASI METHOD

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1. OBJECTIVE

The objective of this handbook is to provide a guide for evaluating physical security of nuclear facilities using the "Estimate of Adversary Sequence Interruption (EASI)" method and a hand-held programmable calculator. The handbook is intended for use by personnel at facilities where special nuclear materials (SNM) are used, processed, or stored. It may also be used as a design aid for such facilities by potential licensees.

2. BACKGROUND

The Nuclear Regulatory Commission (NRC) has the responsibility for formulating and implementing regulations for safeguarding the nuclear fuel cycle with regard to both theft of SNM and sabotage of vital equipment within the facilities. The NRC is currently considering a new approach to safeguards regulation directed toward establishing performance requirements rather than prescribing system elements. This new approach should provide sufficient latitude and economic incentive for improved safeguards system design; however, a workable system of design, license review, and inspection must be demonstrated to the satisfaction of NRC, industry, and the public before new procedures can be adopted. The EASI method is a simple technique which can serve as either a physical protection system design aid or as a decision aid in the licensing and inspection process.

3. DISCUSSION

3.1 The EASI Method

The basis for the EASI method is that, for resolute theft or sabotage attempts to be averted at nuclear facilities, the response force* must be notified of the attempt while there is still sufficient time remaining in the adversary's action sequence for the force to respond and interrupt the sequence. The response force is assumed to be adequate at least to delay adversary progress until additional forces arrive to neutralize the adversary. The actual force composition required is a function of the threat and must be determined by other means.

---

*Although the term response force is used throughout this methodology development, other suitable alternatives to the use of force may be substituted provided they are adequate to delay adversary progress until the adversary can be neutralized.

The EASI evaluation method is a probabilistic approach which evaluates the interaction of basic functions of the physical protection system (detection, assessment, communications, and delay) with guard response time and provides an estimate of adversary sequence interruption. These functions will be discussed as they are encountered in the development of the evaluation procedure. The mathematical methodology for the EASI method is contained in Appendix A, and a glossary of selected safeguards terms is contained in Appendix B.

The steps for applying the EASI method are:

a. Obtain, or develop, a site and plant layout, including design and operational characteristics, in sufficient detail to identify adversary targets as a function of hypothesized adversary goals, motivations and attributes.

b. Generate adversary action sequences relevant to the targets identified.

c. Define the physical paths corresponding to the selected action sequence and choose a specific path, or set of paths, for analysis.

d. Determine locations of detectors and delay mechanisms along the selected path.

e. Obtain data for the probabilities of detection for all detectors and the probability of communication success.

f. Obtain the means and standard deviations of the time for each of the adversary tasks.

g. Obtain the mean and standard deviation of the security force response time.

h. Perform the necessary calculations, using a hand-held programmable calculator and the input data determined to be applicable for the selected adversary path, to determine the probability of interruption.

i. Analyze other possible paths using the same technique in order to determine if any paths produce an unacceptably low probability of interruption. If so, then such information should be considered in formulating the safeguards adequacy statement for the existing facility or proposed design.

j. During the design of a physical protection system, if unacceptably low probabilities of interruption are encountered, change input parameters;

e.g., security force response time, communications probability and detector probability, one at a time to determine the impact of such changes on the overall probability of interrupting the adversary sequence.

3.2 Selection of Adversary Action Sequence

In the context of nuclear facility safeguards, the adversary action sequences which should be considered will both begin and end at some point at or interior to the outermost facility boundary. The two primary functional objectives of the facility safeguards system are:

- Protect against the in situ release of radiotoxic material into an inhabited environment and
- Protect against the successful removal (theft) of SNM from the facility boundary.

Action sequences should be defined which cover all possible generic adversary actions that may lead to the failure of the above objectives and for which measures of safeguards effectiveness can be defined. An exhaustive set of terminations for these sequences which, if protected against, would insure the accomplishment of the two primary objectives are:

- Unauthorized removal of SNM from the facility boundary.
- Acquisition of (autonomous control over) radiotoxic or special nuclear material.
- Intentional compromise of subsystems or components which control the release of radiotoxic material.

In addition to these sequence terminations others which should be considered independently in order to provide protection in depth and balanced protection against multistaged adversary actions are:

- Unauthorized access to both SNM locations and subsystems or components which control the release of radiotoxic material.
- Authorized adversary access to both SNM locations and subsystems or components which control the release of radiotoxic material.

Protection against authorized adversary access is considered to be a responsibility of plant management and national clearance procedures, both of which try to prevent granting authorization to a potential adversary through the use of background checks, clearances, reliability checks, etc.

Action sequences generally are initiated at any transition from an authorized to an unauthorized act. Individuals having no authorized access generally initiate action sequences external to facility boundaries.

Employees with some type of access authorization may initiate a sequence at any boundary interior to the facility boundary. An exhaustive set of adversary action sequence evaluations should consider sequences which initiate at each level or category of authorization and which terminate at those conditions which have been outlined.

The set of adversary attributes which must be considered for any selected action sequences is generally limited by the capability of the safeguards system which exists exterior to the boundary at which the unauthorized action initiates. For example, adversary numbers and resources (tools, high explosives, training, etc.) for any unauthorized act beginning at the facility boundary would be limited by the ability of a national, regional, or local safeguards structure to detect, assess, and neutralize any adversary preparation, training, collection of resources, etc. On the other hand, the numbers of adversaries with some access authorization would be limited by the capability of the personnel clearance, and their resources would be limited by portal contraband detection systems.

The attributes which describe the adversary should include such items as number, training, weapons, information, transportation, hardware resources, etc. The description of these adversary attributes along with the facility description and other environmental constraints determines the performance of the various components of the safeguards system. These measures of component performance are then the inputs to the EASI model to analyze any physical path which has been selected from a given generic adversary action sequence.

3.3 Selection of Physical Path

Following the selection of an adversary action sequence, the next consideration is devoted to the selection of a physical path. Figure 1 is presented both as an example of a facility to be protected and as the facility used for the numerical examples which follow. The location of the special nuclear materials and/or vital components are indicated. The starting point for a path is defined

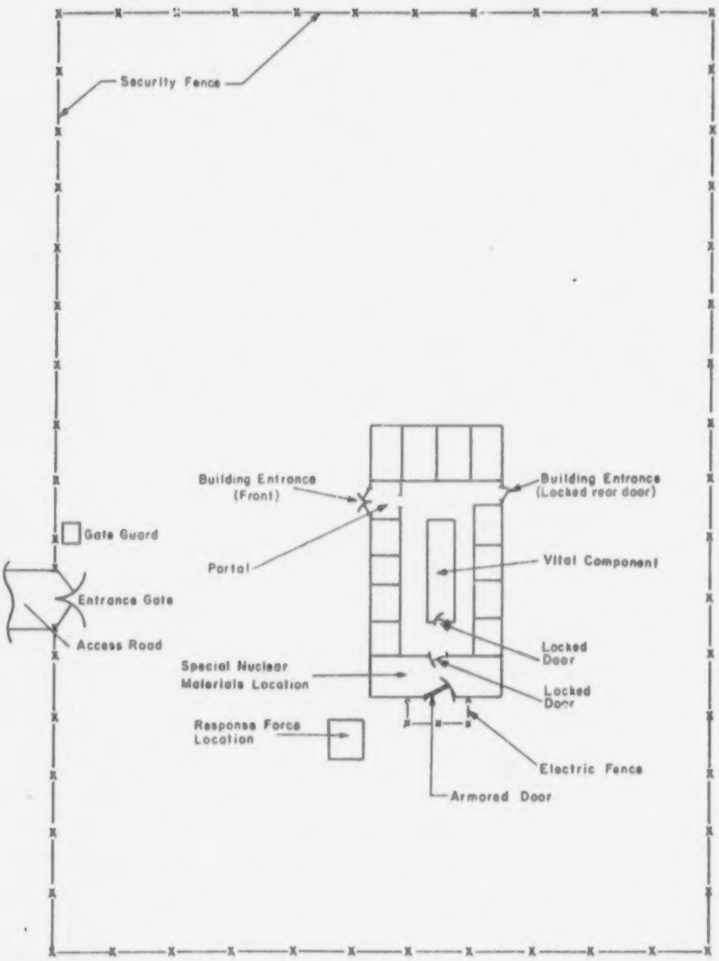

Security Fence
Building Entrance (Front)
Building Entrance (Locked rear door)
Gate Guard
Portal
Vital Component
Entrance Gate
Access Road
Locked Door
Special Nuclear Materials Location
Locked Door
Response Force Location
Electric Fence
Armored Door

Figure 1. Example of Facility to be Protected

as the point where an unauthorized act commences; e.g., penetrating the boundary fence. The terminal point for a path is defined as the point by which adversary progress is to be stopped. It could be the location of the SNM or vital component, or the plant boundary. With a starting point and a terminal point designated by the adversary action sequence classification, the remainder of the path must be selected for analysis.

3.4 Location of Protective Barriers

The protective barriers for the facility should be identified and located on the facility layout. In Figure 1, the barriers could be: (1) the security fence, (2) the locked exterior doors to the building, (3) an electric fence around the SNM access area, (4) the armored door to the SNM room, (5) the locked door to the vital component room, and/or (6) the locked door to the SNM room.

Some determination must be made of the time required to penetrate protective barriers. The purpose of Appendix C is to provide some general guidance based upon a limited amount of actual test data.

3.5 Location of Sensors and Probability of Detection

Detection systems are composed of sensors, signal communications, assessment methods, information display and control units, and power supplies. The purpose of detection systems is to uncover adversary actions such as unauthorized entry attempts into the facility or into particular areas within the facility, smuggling of contraband into the facility, and theft of SNM.

The performance of any detection system depends strongly on the following factors:

- The applicability of the sensor type to the required task
- The compatibility of the equipment with the physical and environmental conditions within which the system must function
- The installation design and maintenance procedures.

An "Intrusion Detection Systems Handbook"[1] has been published to provide guidance and procedures covering the above factors for intrusion detectors.

While these same factors should apply to portal control detection systems for contraband material and SNM, the state of the art has not yet progressed to the point of producing a similar handbook. Information extracted from the "Intrusion Detection Systems Handbook" is contained in Appendix D. This Appendix should provide the reader with a general knowledge of intrusion detection systems.

In the EASI method the location of each sensor should be identified and located on the facility layout. In Figure 1, the sensors could be: (1) closed circuit TV coverage of the area between the fence and the building, (2) a magnetic switch on the locked external building doors, (3) a strain sensing device on the electric fence, (4) an employee or guard within the building, (5) alarms on the internal doors leading to the vital component or SNM rooms, and (6) neutron and gamma ray detectors at one or more locations. The probability of detection for each sensor should be determined based upon test data describing the operation of the sensor within the particular environment.

Contained in the probability of detection are: (1) the probability that the detector will sense abnormal activities, (2) the probability that this indication will be transmitted to an evaluation point; e.g., some control station, and (3) the probability that a valid signal is so declared. If these probabilities of each activity are independent, the overall probability of detection, P(d), can be calculated as

$$P(d) = P_s \times P_t \times P_v$$

where

P_s is the probability the sensor detects the abnormal activity, P_t is the probability that a signal is transmitted, and P_v is the probability that the signal is declared to be valid. If $P_s = 0.8$, $P_t = 0.9$, and $P_v = 0.95$ the solution for P(d) is 0.684.

3.6 Determination of Adversary Time Requirements Along Selected Path

After determining the path and locating the barriers and detectors on this path, the time required for the adversary to perform each task along the path from the starting point to the terminal point must be identified. All adversary task times are defined in terms of their means and standard deviations. A time-sequenced path could be developed as shown in Figure 2. Note that adversary task time divisions occur at each sensor. The estimate of mean times $\{E(t_i)$, i varies from 1 to 7 in Figure 2$\}$ will normally be based upon analyses and/or tests conducted by the evaluator/investigator. For example, if results from six tests indicated that it took 7, 5, 3, 6, 4 and 5 minutes for the assumed adversary to open the external door, the mean time would be

$$E(t_4) = \frac{1}{n}\sum_{j=1}^{n} t_j \qquad (1)$$

where $E(t_4)$ is the estimate of mean time for t_4 on Figure 2, n is the number of tests, and t_j is the time for each test, for n equals 1 through 6.

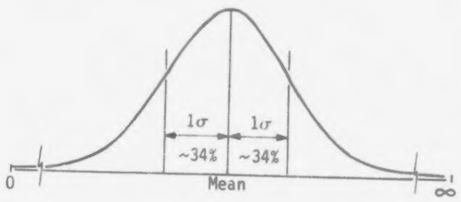
With the six test times given above, the solution is $E(t_4) = (7+5+3+6+4+5)/6 =$ 5 minutes.

The standard deviation, is determined by

$$\sigma(t_4) = \left[\frac{1}{n}\sum_{j=1}^{n} \left\{t_j - E(t_4)\right\}^2\right]^{1/2} \qquad (2)$$

where $\sigma(t_4)$ is the standard deviation for t_4 on Figure 2. With the six test times given above, the solution is $\sigma(t_4) = [\{(7-5)^2+(5-5)^2+(3-5)^2+(6-5)^2+(4-5)^2+(5-5)^2\}/6]^{1/2}$ = 1.29 minutes.

For a normal distribution (based upon a large number of tests), the standard deviation would include approximately ±34 percent of all of the test times, about 68 percent of the test times would be within ± one standard deviation as shown below.



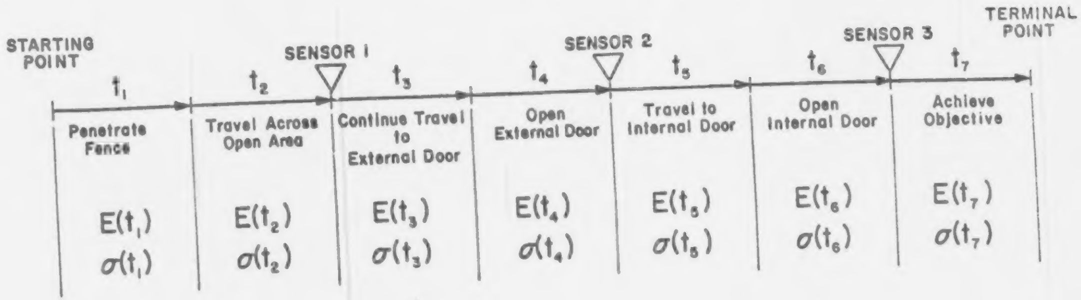

STARTING POINT
SENSOR I
SENSOR 2
SENSOR 3
TERMINAL POINT
t_1
t_2
t_3
t_4
t_5
t_6
t_7
Penetrate Fence
Travel Across Open Area
Continue Travel to External Door
Open External Door
Travel to Internal Door
Open Internal Door
Achieve Objective
$E(t_1)$
$\sigma(t_1)$
$E(t_2)$
$\sigma(t_2)$
$E(t_3)$
$\sigma(t_3)$
$E(t_4)$
$\sigma(t_4)$
$E(t_5)$
$\sigma(t_5)$
$E(t_6)$
$\sigma(t_6)$
$E(t_7)$
$\sigma(t_7)$

Figure 2. Adversary Time-Sequence Path (Example only)

3.7 Communications

The analysis of the probability of communication, P(C), to the response force, starts with an analysis of each communication system employed. For independent systems; e.g., where a warning signal is sent by two or more independent paths such as hard-wire transmission and radio, the overall probability of receiving an alarm (from at least one of two independent transmission methods) is

$$P(C) = [1 - (P_{fa} \times P_{fb})] \tag{3}$$

where P(C) is the probability of communication system success (at least one signal is received), P_{fa} is the probability that the signal from communication system A will not be received (hard-wire transmission for example), and P_{fb} is the probability that the signal from communication system B will not be received (radio transmission for example).

The probability of failure is equal to one minus the probability of success for each system; i.e., $P_f = 1 - P_s$. If the probability of successfully transmitting a signal by hard-wire is $P_{sa} = 0.9$ and the probability of successfully transmitting a signal by radio is $P_{sb} = 0.8$, the probabilities of failure are $P_{fa} = 0.1$ and $P_{fb} = 0.2$, respectively, and P(C) = 0.98.

For three systems in parallel, the probability of communication P(C), receiving a signal from at least one system, is an expansion of (3), or

$$P(C) = [1 - (P_{fa} \times P_{fb} \times P_{fc})] \tag{4}$$

(Note that this calculation is different from P(d) where all actions had to succeed, not just one.)

3.8 Response Times

The time required for the response force to travel to the terminal point must be evaluated. Again, depending upon the specific adversary action sequence being considered, the terminal point may be the location of the SNM or the vital components, the facility boundary, or another specified position. An estimate of the expected response time $\{E(t_r)\}$ and the standard deviation of the response time

($\sigma(t_r)$) must be determined. These times are calculated in a manner similar to adversary times (3.6); however, for each path selected, only one pair of times for $E(t_r)$ and $\sigma(t_r)$ is used in the EASI method. The response time should include (1) the time delays in receiving a system alarm, (2) the time required to assess the warning, and (3) the time required to travel to the terminal point. The evaluator/inspector must analyze the locations of the response force and the terminal point, the method of operation for such forces, and other time delays in arriving at times for $E(t_r)$ and $\sigma(t_r)$. Tests may be conducted under several different conditions and the response times evaluated in a manner similar to adversary times.

4. EXAMPLES

The EASI program is utilized to obtain the probability of interrupting the adversary sequence for: (1) a particular adversary path, (2) a specified expected time and standard deviation for the response time, (3) one probability of communications, (4) specified probabilities of detection for each sensor, and (5) specified expected times and standard deviations associated with each adversary task. The estimate of adversary sequence interruption probability obtained as a solution with the specified inputs is primarily useful as a number with which to compare other solutions based upon different input data. As an example, if several solutions are obtained by using different response times (and holding other parameters constant), the results could be plotted as shown in Figure 3. The EASI program, coupled with a computer with a graphic output, is designed to provide the evaluator with this plotting capability; however, evaluations with a hand-held calculator are limited to a reasonable number of solutions.

After collecting the input data discussed in Section 3, an estimate of adversary sequence interruption can be obtained by the use of the EASI program and a hand-held programmable calculator. Programs and examples of their use have been developed for the Texas Instruments, SR-52 and the Hewlett-Packard, HP-67 programmable calculators. Basic examples of the use of the EASI program on these two calculators are provided in the following paragraphs. These examples are illustrative and the data used should not be construed as typical values.

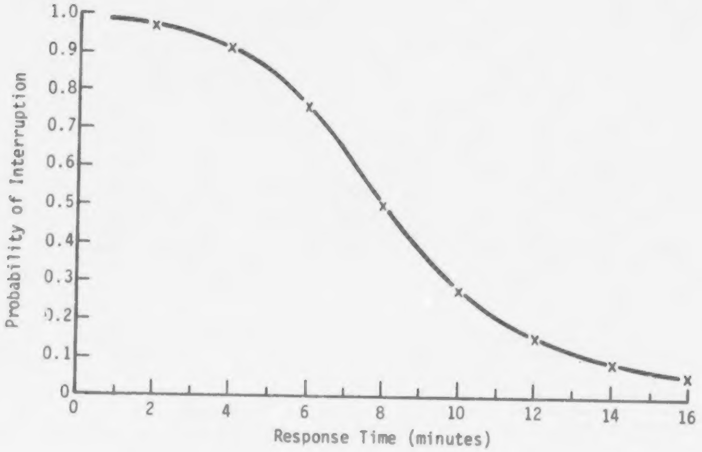


Figure 3. Solution Based on Finite Numbers of Response Times

4.1 SR-52 Examples

The following basic examples, along with several modifications to these basic examples, were run on the Texas Instruments SR-52:

Example	Situation
1	Case A - Saboteur, Outsider
2	Case B - Thief, Insider
3	Case C - Thief, Outsider
4	Case D - Saboteur, Insider

The SR-52 programmable calculator is shown in Figure 4. Most of the keys on the SR-52 are double labeled — a label on the key itself and one just above it. These keys have two functions; the first function is denoted by the label on the key and is activated simply by depressing the key, the second function is the label above the key and is activated by depressing the $\boxed{\text{2nd}}$ button and then the function key. For example, to activate the A′ function, depress the $\boxed{\text{2nd}}$ button followed by the $\boxed{\text{A}}$ button.

To store the contents of a program written on magnetic cards into the calculator the following procedures apply:

a. Turn power on (located at the top, right side).

b. Read side A of the selected magnetic card as follows: press $\boxed{\text{CLR}}$ then $\boxed{\text{2nd}}$ then $\boxed{\text{read}}$ keys and insert the card in the lower slot located on the right hand side of the calculator with the ⬅A■ pointed to the left as shown on Page 21. Do not restrict or hold the card after it is caught by the drive motor. The display will remain blank until the calculator has completed reading side A.

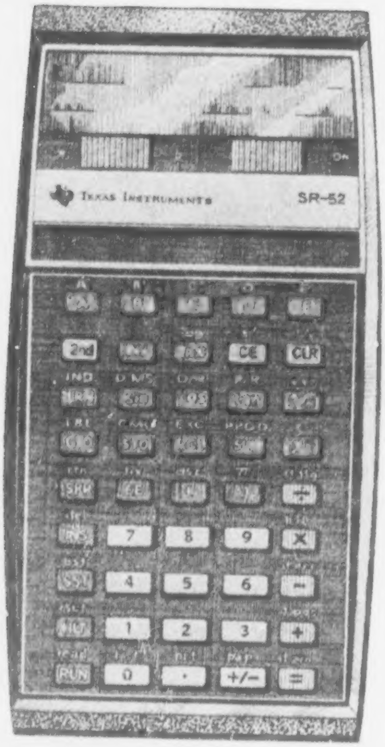
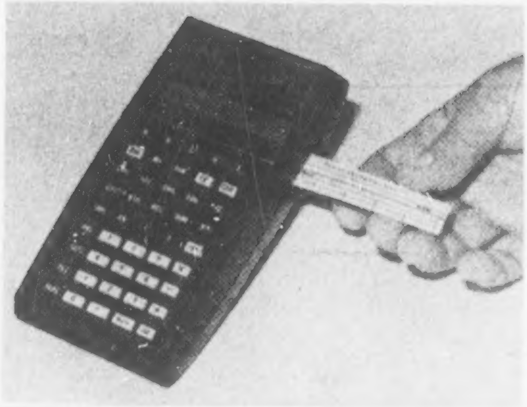
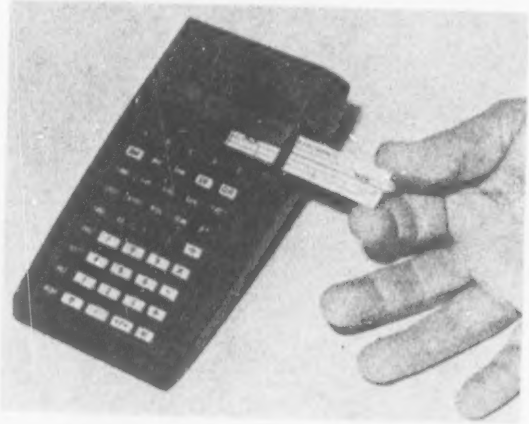


Figure 4. Texas Instruments, SR-52 Programmable Calculator



c. After the drive motor stops, remove the card from the left side of the calculator and insert it into the upper slot on the calculator so that side A of the card shows in the window above keys $\boxed{A}$ through $\boxed{E}$, as shown below.



d. If the display flashes immediately following step b repeat the procedure. If difficulty persists, refer to "Maintenance and Service Information" in the owner's manual.

The program is now loaded into program memory and will remain there until the calculator is either turned off, another card is read, or new instructions are keyed in by passage to the learn mode (LRN button).

The magnetic cards have the ability to retain information placed on them for an indefinite amount of time. The recorded information does not tend to fade or weaken with age and will remain unchanged until actually altered by an external magnetic field. While the magnetic signal will not deteriorate, the physical characteristics of the card and the card drive unit in the calculator are susceptible to damage.

CAUTION: Prerecorded magnetic cards may be damaged or altered if exposed to dust or foreign materials, permanent magnets, or electromagnetic fields such as near electric motors or power transformers.

(Note: The EASI Program for the SR-52 is listed in Appendix E.)

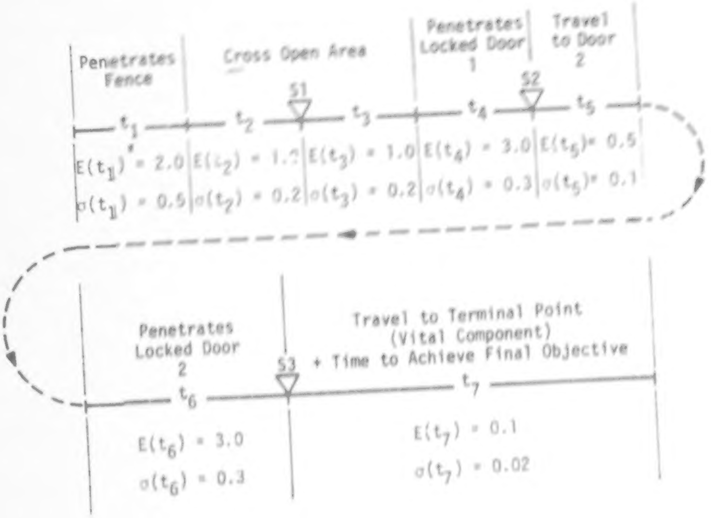
EXAMPLE 1

CASE A - SABOTEUR, OUTSIDER

The path chosen for analysis is shown in Figure 1-1 and has the following sequence:

1. The adversary penetrates the boundary fence, t_1, crosses the area between the fence and the facility's main building, t_2 and t_3, and reaches locked exterior door.
2. While outside, the adversary is subject to surveillance by CCTV, (Sensor 1).
3. After penetrating the exterior door, t_4, (Sensor 2), the adversary continues along a corridor to a second locked door, t_5.
4. The adversary penetrates this locked door, t_6, (Sensor 3) and enters a room containing the vital component, t_7.

The adversary time-sequence path (in minutes) is shown below:



Penetrates Fence
Cross Open Area
Penetrates Locked Door 1
Travel to Door 2
S1
S2
t_1
t_2
t_3
t_4
t_5
$E(t_1)^* = 2.0$
$\sigma(t_1) = 0.5$
$E(t_2) = 1.2$
$\sigma(t_2) = 0.2$
$E(t_3) = 1.0$
$\sigma(t_3) = 0.2$
$E(t_4) = 3.0$
$\sigma(t_4) = 0.3$
$E(t_5) = 0.5$
$\sigma(t_5) = 0.1$
Penetrates Locked Door 2
Travel to Terminal Point (Vital Component) + Time to Achieve Final Objective
S3
t_6
t_7
$E(t_6) = 3.0$
$\sigma(t_6) = 0.3$
$E(t_7) = 0.1$
$\sigma(t_7) = 0.02$

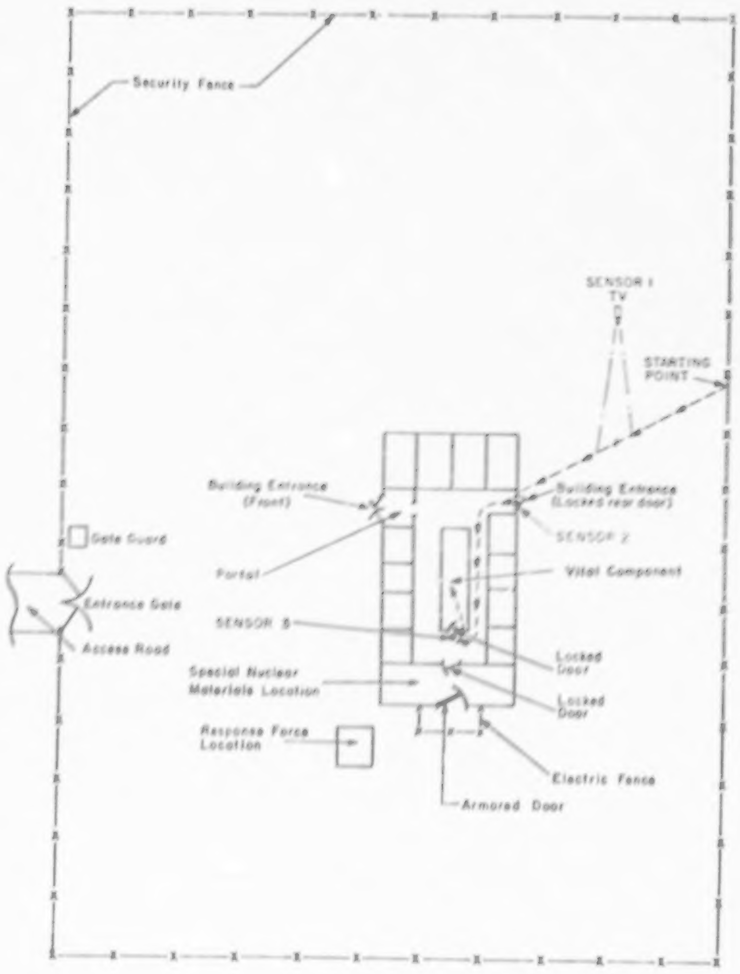

Security Fence
SENSOR 1
TV
STARTING POINT
Building Entrance (Front)
Building Entrance (Locked rear door)
SENSOR 2
Gate Guard
Portal
Vital Component
Entrance Gate
SENSOR 5
Access Road
Locked Door
Special Nuclear Materials Location
Locked Door
Response Force Location
Electric Fence
Armored Door

Figure 1-1. Adversary Sequence, Example 1, SR-52

NOTES:

1. Adversary times must be divided at sensor locations; e.g., the time to cross the open area, t_2+t_3, is arbitrarily divided in half in this example under the assumption that the TV coverage, Sensor 1, will detect movement close to the middle of the open area.
2. The detection probabilities P(d) for the three sensors are: S1 = 0.3, S2 = 0.97, S3 = 0.97.
3. The communication probability P(C) is 0.9.
4. The response time of the security force is $E(t_r) = 4.0$ minutes with a $\sigma(t_r) = 0.16$ minutes.

With the given input information, the estimate of adversary interruption is calculated as shown below:

Step	Procedure	Press (In Order)	Display Indicates
1	Enter Program (A)*		0
2	Initialize Program	E	0
3	Enter Expected Response Time, $E(t_r)$	4, 2nd, A′	4
4	Enter Standard Deviation of Response Time, $\sigma(t_r)$	0.16, 2nd, B′	0.0256
5	Enter Probability of Communication, P(C)	0.9, 2nd, C′	0.9
6	Enter Expected Time for Task 7, $E(t_7)$-Closest to Terminal Point	0.1, A	0.1
7	Enter Standard Deviation for Task 7, $\sigma(t_7)$	0.02, B	0.0004
8	Enter Sensor Probability of Detection P(d) for S3	0.97, C	1.213122282-18**
9	Enter Expected Time for Task 6, $E(t_6)$	3, A	3
10	Enter Standard Deviation for Task 6, $\sigma(t_6)$	0.3, B	0.09
11	Enter Expected Time for Task 5, $E(t_5)$	0.5, A	0.5
12	Enter Standard Deviation for Task 5, $\sigma(t_5)$	0.1, B	0.01
13	Enter Sensor Probability of Detection P(d) for S2	0.97, C	0.1120440888**

(Continued on Next Page)

Step	Procedure	Press (In Order)	Display Indicates
14	Enter Expected Time for Task 4, $E(t_4)$	3, A	3
15	Enter Standard Deviation for Task 4, $\sigma(t_4)$	0.3, B	0.09
16	Enter Expected Time for Task 3, $E(t_3)$	1.0, A	1
17	Enter Standard Deviation for Task 3, $\sigma(t_3)$	0.2, B	0.04
18	Enter Sensor Probability of Detection P(d) for S1	0.3, C	0.352***

*If the SR-52 has been turned off, the EASI program must be reentered. If the SR-52 has not been turned off, press the E button and proceed with Step 3.

**Blank for a few seconds before number displayed, do not press another key until number appears on display.

***This number is the probability of interruption (rounded from 0.3517906773).

NOTES: (1) Adversary times and sensors are entered in order from the terminal point, not the starting point.

(2) The times for $E(t_2)$ and $E(t_3)$ assumed that the sensor point of detection was halfway (in time) between the fence and the door.

(3) Adversary times which are closer to the starting point than the first sensor are not part of the solution.

EXAMPLE 1.A

For comparison purposes, suppose the first sensor was replaced by an improved TV system with automatic alarm features and with a probability of detection of 0.8. The new solution is as follows:

Step	Procedure	Press (In Order)	Display Indicates
1	Enter Program (A)*		0
2	Initialize Program	E	0
3	Enter $E(t_r)$	4, 2nd, A´	4
4	Enter $\sigma(t_r)$	0.16, 2nd, B´	0.0256
5	Enter P(C)	0.9, 2nd, C´	0.9
6	Enter $E(t_7)$	0.1, A	0.1
7	Enter $\sigma(t_7)$	0.02, B	0.0004
8	Enter P(d) for S3	0.97, C	1.213122282-18**
9	Enter $E(t_6)$	3, A	3
10	Enter $\sigma(t_6)$	0.3, B	0.09
11	Enter $E(t_5)$	0.5, A	0.5
12	Enter $\sigma(t_5)$	0.1, B	0.01
13	Enter P(d) for S2	0.97, C	0.1120440888**
14	Enter $E(t_4)$	3, A	3
15	Enter $\sigma(t_4)$	0.3, B	0.09
16	Enter $E(t_3)$	1.0, A	1
17	Enter $\sigma(t_3)$	0.2, B	0.04
18	Enter P(d) for S1	0.8, C	0.751***

*If the SR-52 has been turned off, the EASI program must be reentered. If the SR-52 has not been turned off, press the E button and proceed with Step 3.

**Blank for a few seconds before number displayed, do not press another key until number appears on display.

***This number is the probability of interruption (rounded from 0.7513683248).

EXAMPLE 1.B

For comparison purposes, change Sensor 1 back to the original P(d) = 0.3 but reduce the security response time to $E(t_r) = 2$ min with $\sigma(t_r) = 0.16$ min; e.g., by moving response force closer to vital component. The new solution is as follows:

Step	Procedure	Press (In Order)	Display Indicates
1	Enter Program (A)*		0
2	Initialize Program	E	0
3	Enter $E(t_r)$	2, 2nd, A´	2
4	Enter $\sigma(t_r)$	0.16, 2nd, B´	0.0256
5	Enter P(C)	0.9, 2nd, C´	0.9
6	Enter $E(t_7)$	0.1, A	0.1
7	Enter $\sigma(t_7)$	0.02, B	0.0004
8	Enter P(d) for S3	0.97, C	0.0000000017**
9	Enter $E(t_6)$	3, A	3
10	Enter $\sigma(t_6)$	0.3, B	0.09
11	Enter $E(t_5)$	0.5, A	0.5
12	Enter $\sigma(t_5)$	0.1, B	0.01
13	Enter P(d) for S2	0.97, C	0.8725898641**
14	Enter $E(t_4)$	3, A	3
15	Enter $\sigma(t_4)$	0.3, B	0.09
16	Enter $E(t_3)$	1.0, A	1
17	Enter $\sigma(t_3)$	0.2, B	0.04
18	Enter P(d) for S1	0.3, C	0.907***

*If the SR-52 has been turned off, the EASI program must be reentered. If the SR-52 has not been turned off, press the E button and proceed with Step 3.

**Blank for a few seconds before number displayed, do not press another key until number appears on display.

***This number is the probability of interruption (rounded from 0.906990599).

Therefore, changing the security force response time from 4 minutes to 2 minutes increases the probability of adversary interruption from 0.352 to 0.907.

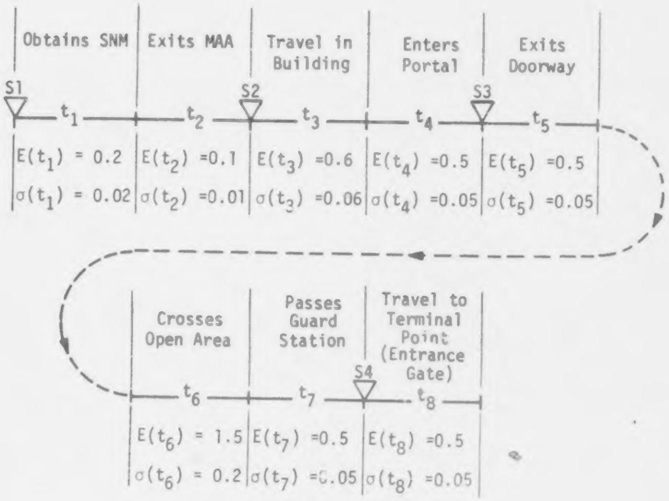
EXAMPLE 2

CASE B - THIEF, INSIDER

The path selected for this analysis is shown in Figure 2-1 and contains the following sequence:

1. An employee has authorized access to the material access area (MAA) where special nuclear materials are stored (he may be observed by other employee(s) and a report may be made, Sensor 1).
2. He attempts to steal some SNM, t_1.
3. He exits the door to the MAA, t_2, (where he may again be observed by other employee(s) who may report the incident, Sensor 2).
4. He travels through the building to the guarded portal, t_3, and enters the portal, t_4, (where he may be detected by neutron and gamma ray sensor, Sensor 3). He exits the doorway, t_5; crosses the facility grounds, t_6; and passes the guard station, t_7, (where a less sensitive radiation detector may sound an alarm, Sensor 4).
5. He then exits the facility through the entrance gate, t_8, (which is considered to be the terminal point).

The adversary time-sequence path (in minutes) is shown below:


Obtains SNM
Exits MAA
Travel in Building
Enters Portal
Exits Doorway
S1
S2
S3
t_1
t_2
t_3
t_4
t_5
$E(t_1) = 0.2$
$\sigma(t_1) = 0.02$
$E(t_2) = 0.1$
$\sigma(t_2) = 0.01$
$E(t_3) = 0.6$
$\sigma(t_3) = 0.06$
$E(t_4) = 0.5$
$\sigma(t_4) = 0.05$
$E(t_5) = 0.5$
$\sigma(t_5) = 0.05$
Crosses Open Area
Passes Guard Station
Travel to Terminal Point (Entrance Gate)
S4
t_6
t_7
t_8
$E(t_6) = 1.5$
$\sigma(t_6) = 0.2$
$E(t_7) = 0.5$
$\sigma(t_7) = 0.05$
$E(t_8) = 0.5$
$\sigma(t_8) = 0.05$

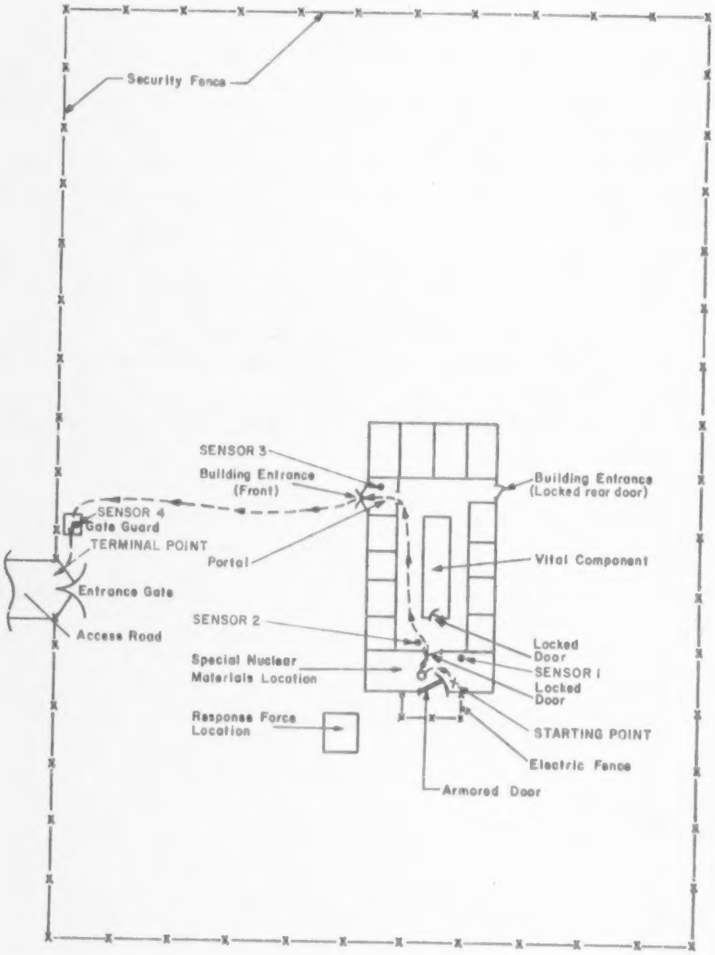

Security Fence
SENSOR 3
Building Entrance (Front)
Building Entrance (Locked rear door)
SENSOR 4
Gate Guard
TERMINAL POINT
Portal
Vital Component
Entrance Gate
Access Road
SENSOR 2
Locked Door
Special Nuclear Materials Location
SENSOR 1
Locked Door
Response Force Location
STARTING POINT
Electric Fence
Armored Door

Figure 2-1. Adversary Sequence, Example 2, SR-52

NOTES:

1. The P(d) for Sensors 1 and 2 is 0.1, P(d) for Sensor 3 is 0.65, and P(d) for Sensor 4 is 0.25.
2. The probability of communication P(C) is 0.9.
3. The estimate (mean) of the response time $E(t_r)$ is one minute and the standard deviation $\sigma(t_r)$ is 0.2 minutes.

With the above input information, the estimate of adversary interruption is calculated as shown below:

Step	Procedure	Press (In Order)	Display Indicates
1	Enter Program (A)*		0
2	Initialize Program	E	0
3	Enter Expected Response Time, $E(t_r)$	1, 2nd, A´	1
4	Enter Standard Deviation of Response Time, $\sigma(t_r)$	0.2, 2nd, B´	0.04
5	Enter Probability of Communication, P(C)	0.9, 2nd, C´	0.9
6	Enter Expected Time for Task 8, $E(t_8)$	0.5, A	0.5
7	Enter Standard Deviation for Task 8, $\sigma(t_8)$	0.05, B	0.0025
8	Enter Probability of Detection, P(d) for S_4	0.25, C	0.0035856163**
9	Enter Expected Time for Task 7, $E(t_7)$	0.5, A	0.5
10	Enter Standard Deviation for Task 7, $\sigma(t_7)$	0.05, B	0.0025
11	Enter Expected Time for Task 6, $E(t_6)$	1.5, A	1.5
12	Enter Standard Deviation for Task 6, $\sigma(t_6)$	0.2, B	0.04
13	Enter Expected Time for Task 5, $E(t_5)$	0.5, A	0.5
14	Enter Standard Deviation for Task 5, $\sigma(t_5)$	0.05, B	0.0025
15	Enter Probability of Detection, P(d) for S_3	0.65, C	0.5864820696**
16	Enter Expected Time for Task 4, $E(t_4)$	0.5, A	0.5

(Continued on Next Page)

Step	Procedure	Press (In Order)	Display Indicates
17	Enter Standard Deviation for Task 4, $\sigma(t_4)$	0.05, B	0.0025
18	Enter Expected Time for Task 3, $E(t_3)$	0.6, A	0.6
19	Enter Standard Deviation for Task 3, $\sigma(t_3)$	0.06, B	0.0036
20	Enter Probability of Detection, $P(d)$ for S_2	0.1, C	0.6236986804**
21	Enter Expected Time for Task 2, $E(t_2)$	0.1, A	0.1
22	Enter Standard Deviation for Task 2, $\sigma(t_2)$	0.01, B	0.0001
23	Enter Expected Time for Task 1, $E(t_1)$	0.2, A	0.2
24	Enter Standard Deviation for Task 1, $\sigma(t_1)$	0.02, B	0.0004
25	Enter Probability of Detection, $P(d)$ for S_1	0.1, C	0.658***

*If The SR-52 has been turned off, the EASI program must be reentered. If the SR-52 has not been turned off, press the E button and proceed with Step 3.

**Blank for a few seconds before number displayed, do not press another key until number appears on display.

***This number is the probability of interruption (rounded from 0.6575657986).

EXAMPLE 2.A

For comparison purposes, delete Sensor 3 at the portal exit and renumber the three sensors to see how this would affect the probability of interruption. The solution becomes:

Step	Procedure	Press (In Order)	Display Indicates
1	Enter Program (A)*		0
2	Initialize Program	E	0
3	Enter $E(t_r)$	1, 2nd, A´	1
4	Enter $\sigma(t_r)$	0.2, 2nd, B´	0.04
5	Enter P(C)	0.9, 2nd, C´	0.9
6	Enter $E(t_8)$	0.5, A	0.5
7	Enter $\sigma(t_8)$	0.05, B	0.0025
8	Enter P(d) for S_3	0.25, C	0.0035856163**
9	Enter $E(t_7)$	0.5, A	0.5
10	Enter $\sigma(t_7)$	0.05, B	0.0025
11	Enter $E(t_6)$	1.5, A	1.5
12	Enter $\sigma(t_6)$	0.2, B	0.04
13	Enter $E(t_5)$	0.5, A	0.5
14	Enter $\sigma(t_5)$	0.05, B	0.0025
15	Enter $E(t_4)$	0.5, A	0.5
16	Enter $\sigma(t_4)$	0.05, B	0.0025
17	Enter $E(t_3)$	0.6, A	0.6
18	Enter $\sigma(t_3)$	0.06, B	0.0036
19	Enter P(d) for S_2	0.1, C	0.0932629073**
20	Enter $E(t_2)$	0.1, A	0.1
21	Enter $\sigma(t_2)$	0.01, B	0.0001
22	Enter $E(t_1)$	0.2, A	0.2
23	Enter $\sigma(t_1)$	0.02, B	0.0004
24	Enter P(d) for S_1	0.1, C	0.175***

*If the SR-52 has been turned off, the EASI program must be reentered. If the SR-52 has not been turned off, press the E button and proceed with Step 3.

**Blank for a few seconds before number displayed, do not press another key until number appears on display.

***This number is the probability of interruption (rounded from 0.1748692455).

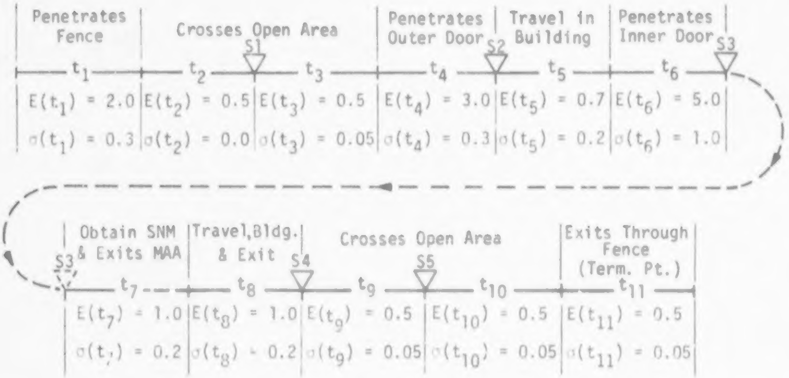
EXAMPLE 3

CASE C - THIEF, OUTSIDER

The path chosen for this analysis is shown in Figure 3-1 and contains the following sequence:

1. The adversary penetrates the boundary fence, t_1, crosses the open area t_2 and t_3, to the building door (where he may be detected by Sensor 1, assumed to be one-half way between fence and the door).
2. He penetrates the building door, t_4, which is protected by Sensor 2.
3. He travels through the building and reaches the door to the material access area (MAA), t_5.
4. He opens the door to the MAA, t_6, which is protected by Sensor 3.
5. He obtains the special nuclear material and exits the MAA, t_7; travels down the hall and exits the external door, t_8, (where a radioactivity detector may detect the SNM, Sensor 4).
6. He crosses the open area, t_9 and t_{10}, where he may be detected by the TV, Sensor 5 (same as Sensor 1).
7. He exits through the security fence and escapes, t_{11}.

The adversary time-sequence path is shown below:


Penetrates Fence
Crosses Open Area
S1
Penetrates Outer Door
S2
Travel in Building
Penetrates Inner Door
S3
t_1
t_2
t_3
t_4
t_5
t_6
$E(t_1) = 2.0$
$\sigma(t_1) = 0.3$
$E(t_2) = 0.5$
$\sigma(t_2) = 0.0$
$E(t_3) = 0.5$
$\sigma(t_3) = 0.05$
$E(t_4) = 3.0$
$\sigma(t_4) = 0.3$
$E(t_5) = 0.7$
$\sigma(t_5) = 0.2$
$E(t_6) = 5.0$
$\sigma(t_6) = 1.0$
Obtain SNM & Exits MAA
S3
Travel, Bldg. & Exit
S4
Crosses Open Area
S5
Exits Through Fence (Term. Pt.)
t_7
t_8
t_9
t_{10}
t_{11}
$E(t_7) = 1.0$
$\sigma(t_7) = 0.2$
$E(t_8) = 1.0$
$\sigma(t_8) = 0.2$
$E(t_9) = 0.5$
$\sigma(t_9) = 0.05$
$E(t_{10}) = 0.5$
$\sigma(t_{10}) = 0.05$
$E(t_{11}) = 0.5$
$\sigma(t_{11}) = 0.05$

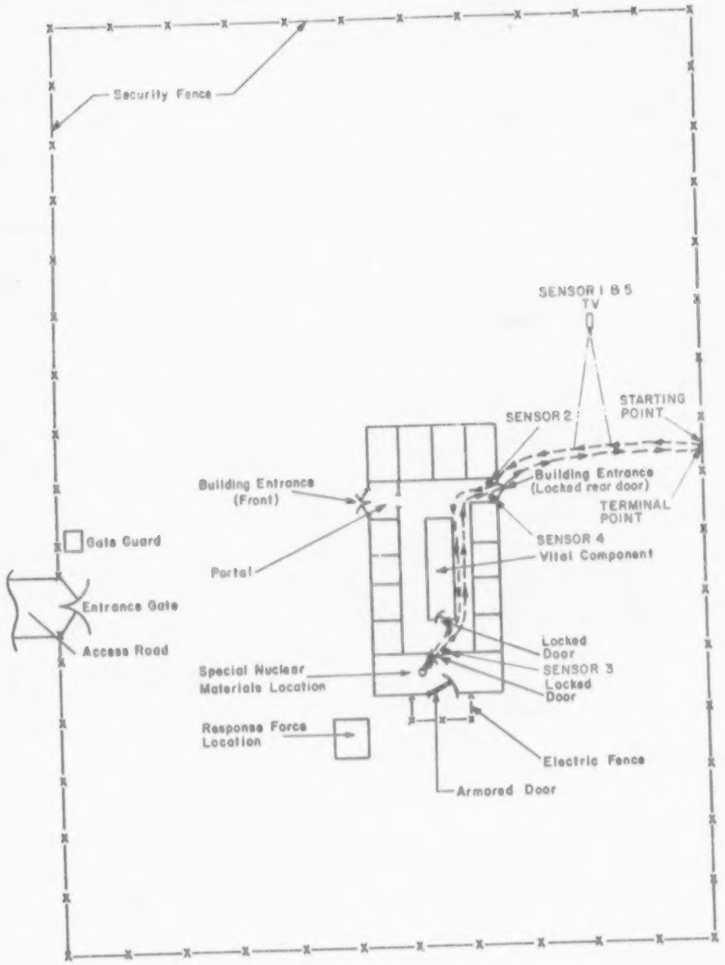

Security Fence
SENSOR 1 & 5
TV
STARTING POINT
SENSOR 2
Building Entrance (Front)
Building Entrance (Locked rear door)
TERMINAL POINT
SENSOR 4
Vital Component
Portal
Gate Guard
Entrance Gate
Access Road
Locked Door
SENSOR 3
Locked Door
Special Nuclear Materials Location
Response Force Location
Electric Fence
Armored Door

Figure 3-1. Adversary Sequence, Example 3, SR-52

NOTES:

1. There are five alarms with the following probabilities of detection: S1 = 0.3, S2 = 0.95, S3 = 0.9, S4 = 0.65, and S5 = 0.3. (It is assumed that both door sensors were disabled upon entry and they were not operative for the exit path.)
2. The probability of communication is 0.9.
3. The response force mean time $E(t_r)$ is 4 minutes with a standard deviation $\sigma(t_r)$ of 0.5 minutes.

With the above input information, the estimate of adversary interruption is calculated as shown below:

Step	Procedure	Press (In Order)	Display Indicates
1	Enter Program (A)*		0
2	Initialize Program	E	0
3	Enter Expected Response Time, $E(t_r)$	4, 2nd, A′	4
4	Enter Standard Deviation for Response Force, $\sigma(t_r)$	0.5, 2nd, B′	0.25
5	Enter Probability of Communications, P (C)	0.9, 2nd, C′	0.9
6	Enter Expected Time for Task 11, $E(t_{11})$-Closest to Terminal Point	0.5, A	0.5
7	Enter Standard Deviation for Task 11, $\sigma(t_{11})$	0.05, B	0.0025
8	Enter Expected Time for Task 10, $E(t_{10})$	0.5, A	0.5
9	Enter Standard Deviation for Task 10, $\sigma(t_{10})$	0.05, B	0.0025
10	Enter Probability of Detection, P(d) for S5	0.3, C	0.0000110965**
11	Enter Expected Time for Task 9, $E(t_9)$	0.5, A	0.5
12	Enter Standard Deviation for Task 9, $\sigma(t_9)$	0.05, B	0.0025
13	Enter Probability of Detection, P(d) for S4	0.65, C	0.0001394112**
14	Enter Expected Time for Task 8, $E(t_8)$	1.0, A	1
15	Enter Standard Deviation for Task 8, $\sigma(t_8)$	0.2, B	0.04

(Continued on Next Page)

Step	Procedure	Press (In Order)	Display Indicates
16	Enter Expected Time for Task 7, $E(t_7)$	1.0, A	1
17	Enter Standard Deviation for Task 7, $\sigma(t_7)$	0.2, B	0.04
18	Enter Probability of Detection, P(d) for S3	0.9, C	0.1522979978**
19	Enter Expected Time for Task 6, $E(t_6)$	5, A	5
20	Enter Standard Deviation for Task 6, $\sigma(t_6)$	1, B	1
21	Enter Expected Time for Task 5, $E(t_5)$	0.7, A	0.7
22	Enter Standard Deviation for Task 5, $\sigma(t_5)$	0.2, B	0.04
23	Enter Probability of Detection, P(d) for S2	0.95, C	0.87662543**
24	Enter Expected Time for Task 4, $E(t_4)$	3.0, A	3
25	Enter Standard Deviation for Task 4, $\sigma(t_4)$	0.3, B	0.09
26	Enter Expected Time for Task 3, $E(t_3)$	0.5, A	0.5
27	Enter Standard Deviation for Task 3, $\sigma(t_3)$	0.05, B	0.0025
28	Enter Probability of Detection, P(d) for S1	0.3, C	0.910***

*If the SR-52 has been turned off, the EASI program must be reentered. If the SR-52 has not been turned off, press the E button and proceed with Step 3.

**Blank for a few seconds before number displayed, do not press another key until number appears on display.

***This number is the probability of interruption (rounded from 0.9099352038).

EXAMPLE 3.A

CASE C - THIEF, OUTSIDER (WITH ASSISTANCE FROM INSIDER)

Suppose the thief was aided by an internal accomplice who attempted to disable S2, S3 and S4, and that the probability of detection by all of these sensors was reduced to 0.1. The solution is modified as follows:

Step	Procedure	Press (In Order)	Display Indicates
1	Enter Program (A)*		0
2	Initialize Program	E	0
3	Enter E (t_r)	4, 2nd, A´	4
4	Enter $\sigma(t_r)$	0.5, 2nd, B´	0.25
5	Enter P(C)	0.9, 2nd, C´	0.9
6	Enter $E(t_{11})$	0.5, A	0.5
7	Enter $\sigma(t_{11})$	0.05, B	0.0025
8	Enter $E(t_{10})$	0.5, A	0.5
9	Enter $\sigma(t_{10})$	0.05, B	0.0025
10	Enter P(d) for S5	0.3, C	0.0000110965**
11	Enter $E(t_9)$	0.5, A	0.5
12	Enter $\sigma(t_9)$	0.05, B	0.0025
13	Enter P(d) for S4	0.1, C	0.0000308372**
14	Enter $E(t_8)$	1.0, A	1
15	Enter $\sigma(t_8)$	0.2, B	0.04
16	Enter $E(t_7)$	1.0, A	1
17	Enter $\sigma(t_7)$	0.2, B	0.04
18	Enter P(d) for S3	0.1, C	0.0169471185**
19	Enter $E(t_6)$	5, A	5
20	Enter $\sigma(t_6)$	1, B	1
21	Enter $E(t_5)$	0.7, A	0.7
22	Enter $\sigma(t_5)$	0.2, B	0.04
23	Enter P(d) for S2	0.1, C	0.1053736905**
24	Enter $E(t_4)$	3.0, A	3
25	Enter $\sigma(t_4)$	0.3, B	0.09

(Continued on Next Page)

Step	Procedure	Press (In Order)	Display Indicates
26	Enter $E(t_3)$	0.5, A	0.5
27	Enter $\sigma(t_3)$	0.05, B	0.0025
28	Enter P(d) for S1	0.3, C	0.347***

*If the SR-52 has been turned off, the EASI program must be reentered. If the SR-52 has not been turned off, press the E button and proceed with Step 3.

**Blank for a few seconds before number displayed, do not press another key until number appears on display.

***This number is the probability of interruption (rounded from 0.3469214339).

Therefore, under the assumptions listed above, the accomplice had reduced the probability of interruption from 0.910 to 0.347.

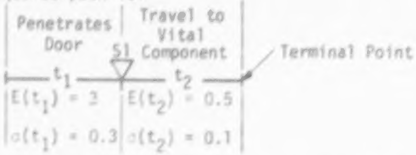
EXAMPLE 4

CASE D - SABOTEUR, INSIDER

Under the assumption that the vital components were in a locked room, an adversary path could be as follows (Figure 4-1):

1. An employee penetrates the locked door, t_1, (which may activate an alarm).
2. He proceeds to the vital component and damages/destroys the equipment, t_2.

The adversary time-sequence path is:



If the expected response time is 4 minutes with a standard deviation of 0.5 minutes, the probability of communication is equal to 0.9, and the probability of detection by Sensor 1 is 0.95, the solution is:

Step	Procedure	Press (In Order)	Display Indicates
1	Enter Program (A)*		0
2	Initialize Program	E	0
3	Enter Expected Response Time, $E(t_r)$	4, 2nd, A'	4
4	Enter Standard Deviation of Response Time, $\sigma(t_r)$	0.5, 2nd, B'	0.25
5	Enter Probability of Communication, P(C)	0.9, 2nd, C'	0.9
6	Enter Expected Time for Task 2, $E(t_2)$ - Closest to Terminal Point	0.5, A	0.5
7	Enter Standard Deviation for Task 2, $\sigma(t_2)$	0.1, B	0.01
8	Enter Probability of Detection P(d), for S_1	0.95, C	0.000**

*If the SR-52 has been turned off, the EAS1 program must be reentered. If the SR-52 has not been turned off, press the E button and proceed with Step 3.

**This number is the probability of interruption (rounded from 0.0000073151).

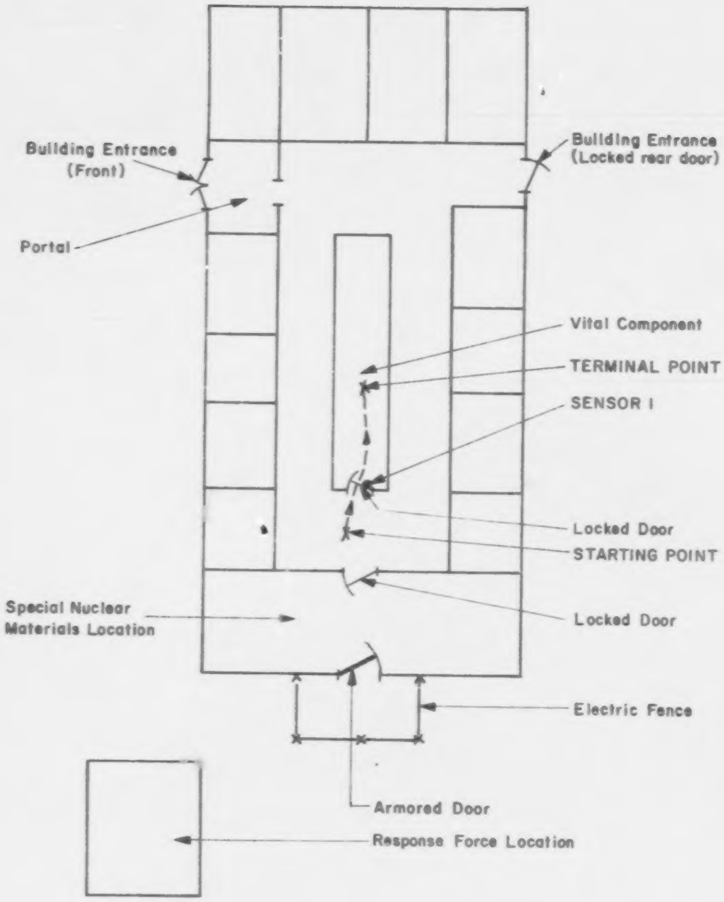

Building Entrance (Front)
Building Entrance (Locked rear door)
Portal
Vital Component
TERMINAL POINT
SENSOR I
Locked Door
STARTING POINT
Locked Door
Special Nuclear Materials Location
Electric Fence
Armored Door
Response Force Location

Figure 4-1. Adversary Sequence. Example 4, SR-52

EXAMPLE 4.A

Since the previous solution yields an unacceptable probability, consider reducing the expected response time to 0.3 minute with a standard deviation of 0.1 minute (by having guards or a buddy system, inside the vital component area at all times). The new solution becomes:

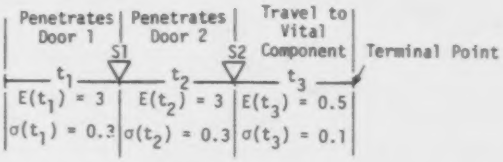
Step	Procedure	Press (In Order)	Display Indicates
1	Enter Program (A)*		0
2	Initialize Program	E	0
3	Enter $E(t_r)$	0.3, 2nd, A´	0.3
4	Enter $\sigma(t_r)$	0.1, 2nd, B´	0.01
5	Enter P(C)	0.9, 2nd, C´	0.9
6	Enter $E(t_2)$	0.5, A	0.5
7	Enter $\sigma(t_2)$	0.1, B	0.01
8	Enter P(d) for S_1	0.95, C	0.784**

*If the SR-52 has been turned off, the EASI program must be reentered. If the SR-52 has not been turned off, press the E button and proceed with Step 3.

**This number is the probability of interruption (rounded from 0.784158297).

EXAMPLE 4.B

An alternate solution could be to add a second door having a sensor with the same probability of detection as the existing door, for a new adversary time-sequence as follows:


Penetrates Door 1
Penetrates Door 2
Travel to Vital Component
Terminal Point
S1
S2
t_1
t_2
t_3
$E(t_1) = 3$
$E(t_2) = 3$
$E(t_3) = 0.5$
$\sigma(t_1) = 0.3$
$\sigma(t_2) = 0.3$
$\sigma(t_3) = 0.1$

If $E(t_r)$ remains 4 minutes and $\sigma(t_r)$ remains 0.5 minutes, P(C) remains 0.9, and P(d) for both Sensors 1 and 2 is 0.95, the solution becomes:

Step	Procedure	Press (In order)	Display Indicates
1	Enter Program (A)*		.0
2	Initialize Program	E	0
3	Enter $E(t_r)$	4, 2nd, A'	4
4	Enter $\sigma(t_r)$	0.5, 2nd, B'	0.25
5	Enter P(C)	0.9, 2nd, C'	0.9
6	Enter $E(t_3)$	0.5, A	0.5
7	Enter $\sigma(t_3)$	0.1, B	0.01
8	Enter P(d) for S_2	0.95, C	0.0000073151**
9	Enter $E(t_2)$	3, A	3
10	Enter $\sigma(t_2)$	0.3, B	0.09
11	Enter P(d) for S_1	0.95, C	0.164***

*If the SR-52 has been turned off, the EASI program must be reentered. If the SR-52 has not been turned off, press the E button and proceed with Step 3.

**Blank for a few seconds before number displayed, do not press another key until number appears on display.

***This number is the probability of interruption (rounded from 0.1642014476).

4.2 HP-67 Examples

The HP-67 programmable calculator is similar to the Texas Instruments, SR-52 in size, external appearance and in the position of the magnetic card reading slot. Although most of the keys on the HP-67 perform three separate functions, the EASI program does not require switching from one set of functions to another. Only the basic keyboard functions are needed for EASI (the $\boxed{f}$ and $\boxed{g}$ functions keys are never used). To store the contents of a program written on magnetic cards the following procedures apply:

a. Turn power on (located at the top, left side).

b. Read side 1 of the selected magnetic card as follows: place the W/PRGM-RUN switch (located at the top, right side) in the RUN position. Insert the card in the slot located on the right hand side of the calculator with the ◀1 pointed to the left (in the same manner as employed with the SR-52). Do not restrict or hold the card after it is caught by the drive motor.

c. After the drive motor stops, remove the card from the left side of the calculator and file it away.

d. If the display shows ERROR following step b, press the CLX button and repeat the procedure beginning with step b. If difficulty persists, refer to "Service and Maintenance" in the owner's manual.

After the program has been read into the calculator, the probability of interruption calculations are performed following the procedures outlined in Examples 5 and 6 on the following pages. If a mistake is made while entering data, press the CLX button and reenter the data beginning with the first entry.

The HP-67 program requires the following data for each Task i: E(t_i), σ(t_i), P(d). If no detection device is associated with Task i, enter zero (0) for P(d).

(NOTE: The EASI Program for the HP-67 is listed in Appendix F.)

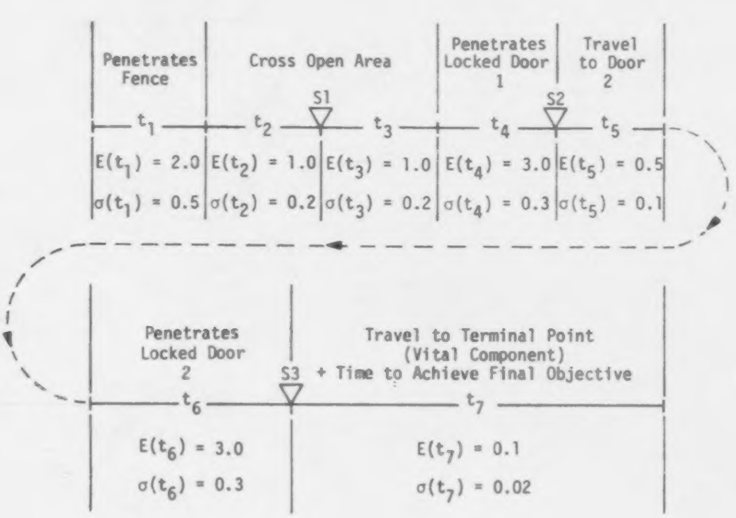
EXAMPLE 5

CASE A - SABOTEUR, OUTSIDER

The path chosen for analysis is shown in Figure 5-1 and has the following sequence:

1. The adversary penetrates the boundary fence, t_1, crosses the area between the fence and the facility's main building, t_2 and t_3, and reaches locked exterior door.
2. While outside, the adversary is subject to surveillance by CCTV, (Sensor 1).
3. After penetrating the exterior door, t_4, (Sensor 2), the adversary continues along a corridor to a second locked door, t_5.
4. The adversary penetrates this locked door, t_6, (Sensor 3), and enters a room containing the vital component, t_7.

The adversary time-sequence path (in minutes) is shown below:



Penetrates Fence
Cross Open Area
Penetrates Locked Door 1
Travel to Door 2
S1
S2
t_1
t_2
t_3
t_4
t_5
$E(t_1) = 2.0$
$\sigma(t_1) = 0.5$
$E(t_2) = 1.0$
$\sigma(t_2) = 0.2$
$E(t_3) = 1.0$
$\sigma(t_3) = 0.2$
$E(t_4) = 3.0$
$\sigma(t_4) = 0.3$
$E(t_5) = 0.5$
$\sigma(t_5) = 0.1$
Penetrates Locked Door 2
Travel to Terminal Point (Vital Component) + Time to Achieve Final Objective
S3
t_6
t_7
$E(t_6) = 3.0$
$\sigma(t_6) = 0.3$
$E(t_7) = 0.1$
$\sigma(t_7) = 0.02$

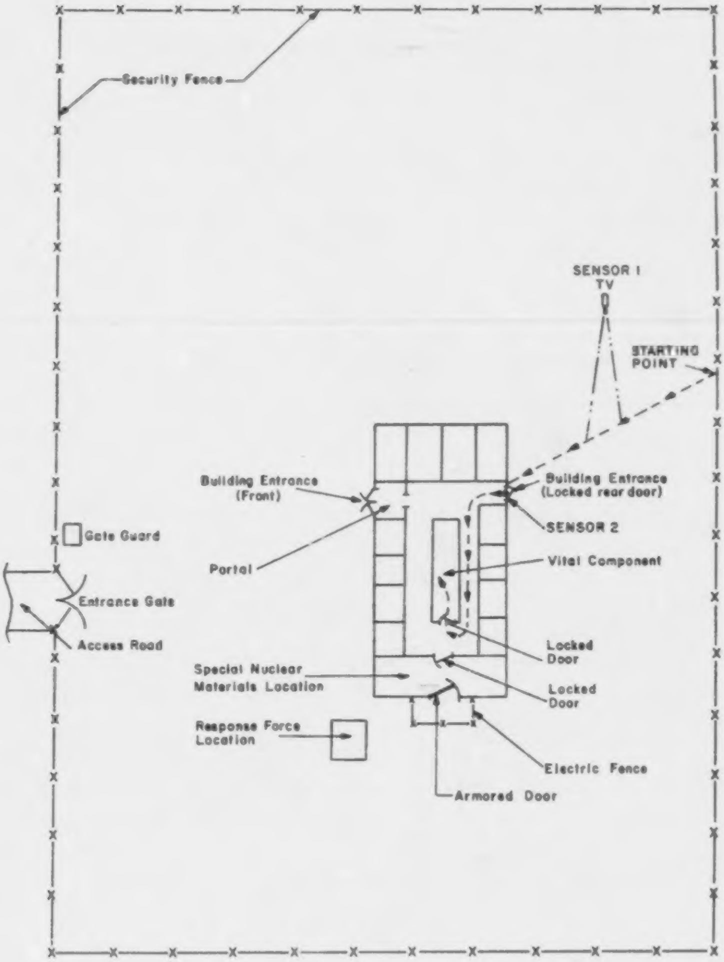

Security Fence
SENSOR I
TV
STARTING
POINT
Building Entrance
(Front)
Building Entrance
(Locked rear door)
SENSOR 2
Gate Guard
Portal
Vital Component
Entrance Gate
Access Road
Locked
Door
Special Nuclear
Materials Location
Locked
Door
Response Force
Location
Electric Fence
Armored Door

Figure 1-5. Adversary Sequence, Example 5, HP-67

NOTES:

1. Adversary times must be divided at sensor locations; e.g., the time to cross the open area, t_2+t_3, is arbitrarily divided in half in this example under the assumption that the TV coverage, Sensor 1, will detect movement close to the middle of the open area.
2. The detection probabilities P(d) for the three sensors are: S1 = 0.3, S2 = 0.97, S3 = 0.97.
3. The communication probability P(C) is 0.9.
4. The response time of the security force is $E(t_r) = 4.0$ minutes with a $\sigma(t_r) = 0.16$ minutes.

With the given input information, the estimate of adversary interruption is calculated as shown on the following page.

EXAMPLE 5

CASE A - SABOTEUR, OUTSIDER

Step	Procedure	Press (In Order)	Display Indicates
1	Enter Program (Side 1)*		0
2	Enter Expected Response Time, $E(t_r)$	4, Enter	4
3	Enter Standard Deviation of Response Time, $\sigma(t_r)$	0.16, Enter	0.16
4	Enter Probability of Communication, P(C)	0.9, A	-4.0**
5	Enter Expected Time for Task 7, $E(t_7)$-Closest to Terminal Point	0.1, Enter	0.1
6	Enter Standard Deviation for Task 7, $\sigma(t_7)$	0.02, Enter	0.02
7	Enter Sensor Probability of Detection, P(d) for S3	0.97, B	1.213122289-18**
8	Enter Expected Time for Task 6, $E(t_6)$	3, Enter	3
9	Enter Standard Deviation for Task 6, $\sigma(t_6)$	0.3, Enter	0.3
10	Enter Zero; No Sensor Probability of Detection Associated with Task 6	0, B	1.213122289-18**
11	Enter Expected Time for Task 5, $E(t_5)$	0.5, Enter	0.5
12	Enter Standard Deviation for Task 5, $\sigma(t_5)$	0.1, Enter	0.1
13	Enter Sensor Probability of Detection, P(d) for S2	0.97, B	0.112044089**†
14	Enter Expected Time for Task 4, $E(t_4)$	3, Enter	3
15	Enter Standard Deviation for Task 4, $\sigma(t_4)$	0.3, Enter	0.3
16	Enter Zero; No Sensor Probability of Detection Associated with Task 4	0, B	0.112044089**†
17	Enter Expected Time for Task 3, $E(t_3)$	1.0, Enter	1
18	Enter Standard Deviation for Task 3, $\sigma(t_3)$	0.2, Enter	0.2
19	Enter Sensor Probability of Detection P(d) for S1	0.3, B	0.351790677***†

*If the HP-67 has been turned off, the EASI program must be reentered. If the HP-67 has not been turned off, press CLX button and proceed with Step 2.

(Continued on Next Page)

**Blank for a few seconds before number displayed, do not press another key until number appears on display.

***This number is the probability of interruption.

†For the HP-67 only two significant figures will normally be displayed following computations (the exception being numbers with a rounded value less than 0.01, which will automatically be displayed in exponential form). In order to display additional significant figures (maximum of 9), press the $\boxed{\text{DSP}}$ key followed by the number of significant figures desired; e.g., depressing $\boxed{\text{DSP}}$ and $\boxed{9}$ will provide the accuracy cited in the example.

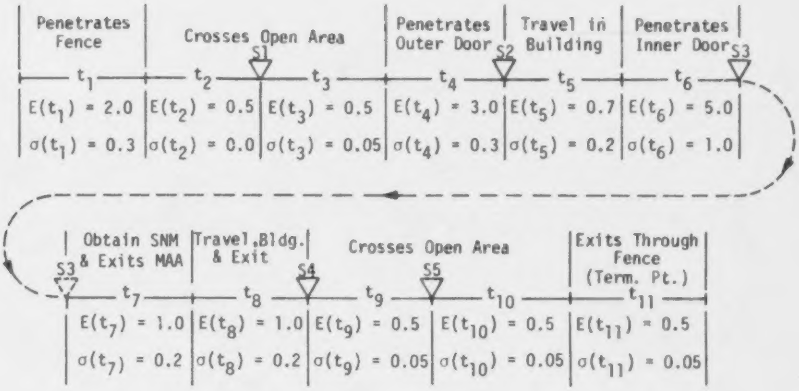
EXAMPLE 6

CASE C - THIEF, OUTSIDER

The path chosen for this analysis is shown in Figure 6-1 and contains the following sequence:

1. The adversary penetrates the boundary fence, t_1, crosses the open area, t_2 and t_3, to the building door (where he may be detected by Sensor 1, assumed to be one-half way between the fence and the door).
2. He penetrates the building door, t_4, which is protected by Sensor 2.
3. He travels through the building and reaches the door to the material access area (MAA), t_5.
4. He opens the door to the MAA, t_6, which is protected by Sensor 3.
5. He obtains the special nuclear material and exits the MAA, t_7; travels down the hall and exits the external door, t_8, (where a radioactivity detector may detect the SNM, Sensor 4).
6. He crosses the open area, t_9 and t_{10}, where he may be detected by the TV, Sensor 5 (same as Sensor 1).
7. He exits through the security fence and escapes, t_{11}.

The adversary time-sequence path is shown below:


Penetrates Fence
Crosses Open Area
S1
Penetrates Outer Door
S2
Travel in Building
Penetrates Inner Door
S3
t_1
t_2
t_3
t_4
t_5
t_6
$E(t_1) = 2.0$
$\sigma(t_1) = 0.3$
$E(t_2) = 0.5$
$\sigma(t_2) = 0.0$
$E(t_3) = 0.5$
$\sigma(t_3) = 0.05$
$E(t_4) = 3.0$
$\sigma(t_4) = 0.3$
$E(t_5) = 0.7$
$\sigma(t_5) = 0.2$
$E(t_6) = 5.0$
$\sigma(t_6) = 1.0$
Obtain SNM & Exits MAA
S3
Travel.Bldg. & Exit
S4
Crosses Open Area
S5
Exits Through Fence (Term. Pt.)
t_7
t_8
t_9
t_{10}
t_{11}
$E(t_7) = 1.0$
$\sigma(t_7) = 0.2$
$E(t_8) = 1.0$
$\sigma(t_8) = 0.2$
$E(t_9) = 0.5$
$\sigma(t_9) = 0.05$
$E(t_{10}) = 0.5$
$\sigma(t_{10}) = 0.05$
$E(t_{11}) = 0.5$
$\sigma(t_{11}) = 0.05$

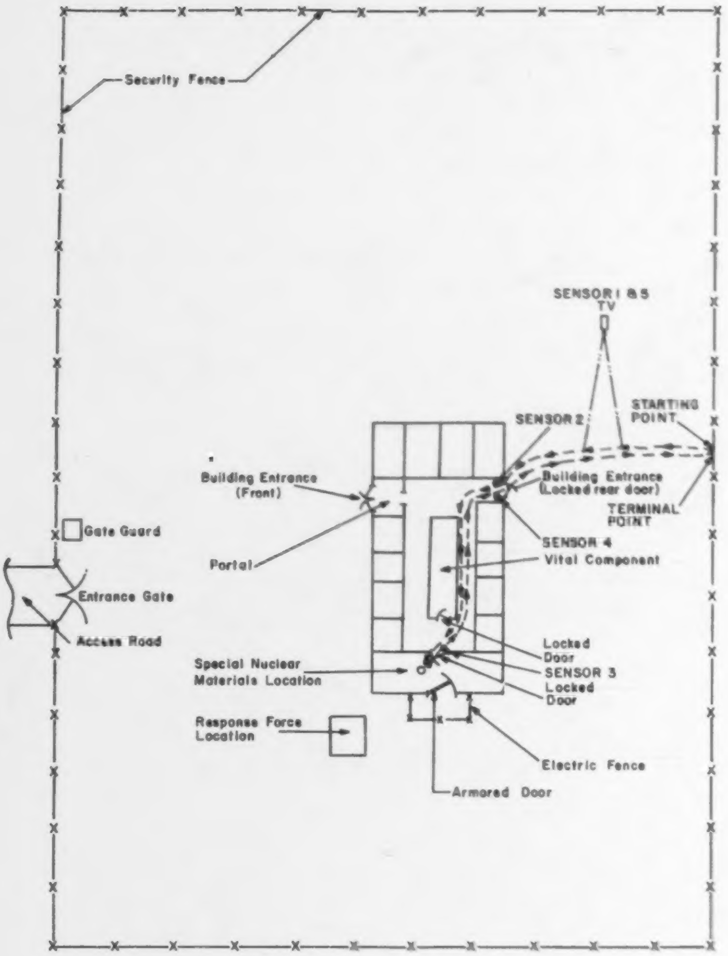

Security Fence
SENSOR 1 & 5
TV
SENSOR 2
STARTING POINT
Building Entrance (Front)
Building Entrance (Locked rear door)
TERMINAL POINT
Gate Guard
Portal
SENSOR 4
Vital Component
Entrance Gate
Access Road
Locked Door
SENSOR 3
Locked Door
Special Nuclear Materials Location
Response Force Location
Electric Fence
Armored Door

Figure 6-1. Adversary Sequence, Example 6, HP-67

NOTES:

1. There are five alarms with the following probabilities of detection: S1 = 0.3, S2 = 0.95, S3 = 0.9, S4 = 0.65, and S5 = 0.3. (It is assumed that both door sensors were disabled upon entry and they were not operative for the exit path.)
2. The probability of communication is 0.9.
3. The response force mean time $E(t_r)$ is 4 minutes with a standard deviation $\sigma(t_r)$ of 0.5 minutes.

With the above input information, the estimate of adversary interruption is calculated as shown on the following page.

EXAMPLE 6

CASE C - THIEF, OUTSIDER

Step	Procedure	Press (In Order)	Display Indicates
1	Enter Program (Side 1)*		0
2	Enter Expected Response Time, $E(t_r)$	4, Enter	4
3	Enter Standard Deviation of Response Time, $\sigma(t_r)$	0.5, Enter	0.5
4	Enter Probability of Communication, P(C)	0.9, A	-4.0**
5	Enter Expected Time for Task 11, $E(t_{11})$-Closest to Terminal Point	0.5, Enter	0.5
6	Enter Standard Deviation for Task 11, $\sigma(t_{11})$	0.05, Enter	0.05
7	Enter Zero; No Sensor Probability of Detection Associated with Task 11	0, B	0**
8	Enter Expected Time for Task 10, $E(t_{10})$	0.5, Enter	0.5
9	Enter Standard Deviation for Task 10, $\sigma(t_{10})$	0.05, Enter	0.05
10	Enter Probability of Detection, P(d) for S5	0.3, B	0.000011097**†
11	Enter Expected Time for Task 9, $E(t_9)$	0.5, Enter	0.5
12	Enter Standard Deviation for Task 9, $\sigma(t_9)$	0.05, Enter	0.05
13	Enter Probability of Detection, P(d) for S4	0.65, B	0.000139411**†
14	Enter Expected Time for Task 8, $E(t_8)$	1.0, Enter	1
15	Enter Standard Deviation for Task 8, $\sigma(t_8)$	0.2, Enter	0.2
16	Enter Zero; No Sensor Probability of Detection Associated with Task 8	0, B	0.000139411**†
17	Enter Expected Time for Task 7, $E(t_7)$	1.0, Enter	1
18	Enter Standard Deviation for Task 7, $\sigma(t_7)$	0.2, Enter	0.2
19	Enter Probability of Detection, P(d) for S3	0.9, B	0.152297998**†

(Continued on Next Page)

Step	Procedure	Press (In Order)	Display Indicates
20	Enter Expected Time for Task 6, $E(t_6)$	5, Enter	5
21	Enter Standard Deviation for Task 6, $\sigma(t_6)$	1, Enter	1
22	Enter Zero; No Sensor Probability of Detection Associated with Task 6	0, B	0.152297998**†
23	Enter Expected Time for Task 5, $E(t_5)$	0.7, Enter	0.7
24	Enter Standard Deviation for Task 5, $\sigma(t_5)$	0.2, Enter	0.2
25	Enter Probability of Detection, P(d) for S2	0.95, B	0.876625430**†
26	Enter Expected Time for Task 4, $E(t_4)$	3.0, Enter	3
27	Enter Standard Deviation for Task 4, $\sigma(t_4)$	0.3, Enter	0.3
28	Enter Zero; No Sensor Probability of Detection Associated with Task 4	0, B	0.876625430**†
29	Enter Expected Time for Task 3, $E(t_3)$	0.5, Enter	0.5
30	Enter Standard Deviation for Task 3, $\sigma(t_3)$	0.05, Enter	0.05
31	Enter Probability of Detection, P(d) for S1	0.3, B	0.909935204***†

*If the HP-67 has been turned off, the EASI program must be reentered. If the HP-67 has not been turned off, press CLX button and proceed with Step 2.

**Blank for a few seconds before number displayed, do not press another key until number appears on display.

***This number is the probability of interruption.

†For the HP-67 only two significant figures will normally be displayed following computations (the exception being numbers with a rounded value less than 0.01, which will automatically be displayed in exponential form). In order to display additional significant figures (maximum of 9), press the $\boxed{\text{DSP}}$ key followed by the number of significant figures desired; e.g., depressing $\boxed{\text{DSP}}$ and $\boxed{9}$ will provide the accuracy cited in the example.

REFERENCES

1. "Intrusion Detection Systems Handbook," SAND76-0554, Sandia Laboratories, OUO, November 1976.

2. Johnson, N.L., and S. Kotz, Distributions in Statistics -- Continuous Univariate Distributions - 2, Houghton Mifflin Co., 1970, p. 6.

3. Sasser, D.W., "EASI on the HP-25, HP-65, and HP-67," SAND76-0597, Sandia Laboratories, May 1977.

APPENDIX A

METHODOLOGY

The basis for the EASI method is that, for resolute theft or sabotage attempts to be averted at nuclear facilities, the response force* must be notified of the attempt while there is still sufficient time remaining in the adversary's action sequence for the force to respond and interrupt the sequence. At this point the response force is assumed to be adequate at least to delay adversary progress until additional forces arrive to neutralize the adversary. The actual force composition required is a function of the threat and must be determined by other means.

In this evaluation method, response force notification of a theft or sabotage attempt is called an alarm, and the probability of alarm is defined as:

$$P(A) = P(D)P(C) \tag{1}$$

where

P(D) = probability of attempt detection,

P(C) = probability of communication to the response force.

For a single detection sensor, the probability of adversary action sequence interruption is

$$P(I) = P(R|A)P(A) \tag{2}$$

where

P(R|A) = conditional probability of response force arrival prior to the end of adversary's action sequence, given an alarm.

As noted earlier, the adversary action sequence takes place along a path with a starting point, followed by a sequence of sensors (or other possible means of detection) and barriers, and a terminal point. If a sensor activates with time t_a remaining for the adversary to reach the designated terminal point, then for an interruption to occur the following relation must hold:

---

*Although the term response force is used throughout this methodology development, other suitable alternatives to the use of force may be substituted provided they are adequate to delay adversary progress until the adversary can be neutralized.

$$t_a - t_r \geq 0 \qquad (3)$$

where

t_a = time remaining for adversary to reach a terminal point when the sensor activates

t_r = time for the security force to respond starting with sensor activation.

Assuming t_a and t_r are independent, normally distributed*, random variables then

$$x = (t_a - t_r) \qquad (4)$$

has a normal distribution with a mean,

$$\mu_x = E(t_a - t_r) = E(t_a) - E(t_r) \qquad (5)$$

and a variance,

$$\sigma_x^2 = \text{var}(t_a - t_r) = \text{var}(t_a) + \text{var}(t_r) \qquad (6)$$

and

$$P(x \geq 0) = \int_0^\infty \frac{1}{\sqrt{2\pi\sigma_x^2}} \exp\left[-\frac{(x - \mu_x)^2}{2\sigma_x^2}\right] dx. \qquad (7)$$

Referring back to Equation (2), it is evident that $P(R|A)$ is equivalent to $P(x \geq 0)$. Furthermore, $P(R|A)$ can be evaluated in terms of the expected values and variances of t_a and t_r using Equations (5) and (6). For example, if

$$E(t_a) > E(t_r) + 2\sigma_x \qquad (8)$$

then $P(R|A) > 0.98$ and Equation (2) can be approximated by

$$P(I) = P(A). \qquad (9)$$

---

*The normal distribution requirement may be approximated by letting t_a and t_r be sums of random variables which satisfy the conditions of the Central Limit Theorem.

If

$$E(t_a) < E(t_r) - 2\sigma_x, \qquad (10)$$

then $P(R|A) < 0.02$ and Equation (2) can be approximated by

$$P(I) \approx 0. \qquad (11)$$

For

$$E(t_r) - 2\sigma_x < E(t_a) < E(t_r) + 2\sigma_x \qquad (12)$$

$P(R|A)$ should be evaluated by Expression 7 or approximated[2] by

$$P(R|A) = \frac{\exp 1.7[\mu_x/\sigma_x]}{1 + \exp 1.7[\mu_x/\sigma_x]}. \qquad (13)$$

Since the method is concerned with the time remaining in the sequence, evaluation of $E(t_a)$ and $\mathrm{var}(t_a)$ at point p along a path of interest must be with respect to the terminal point. The penetration time through each barrier and the transit time between barriers are considered to be random variables with values corresponding to the level of adversary resources. Then, the expected time from any point p to the terminal point n is:

$$E(t_a) \text{ at point } p = \sum_{i=p+1}^{n} E(t_i) \qquad (14)$$

where

$E(t_i)$ = the expected time to perform Task i.

Assuming each task to be independent, the variance of the path time remaining between point p and the terminal point n is:

$$\mathrm{Var}(t_a) \text{ at point } p = \sum_{i=p+1}^{n} \mathrm{var}(ti) \qquad (15)$$

For two or more sensors the conditional probability of response force arrival, $P(R|A)$, for each sensor must be calculated as previously described. Then the cumulative probability of sequence interruption calculated along the adversary's path from the starting point is:

$$P(I) = P(R|A_1)P(A_1) + \sum_{i=2}^{n} P(R|A_i)P(A_i) \prod_{j=1}^{i-1} Q(A_j) \qquad (16)$$

where

$Q(A_j) = 1 - P(A_j)$.

On a multiple sensor path, the contribution of any sensor to the system performance is reduced by the probability that no alarm has occurred prior to detection by that sensor. To illustrate, with two sensors Equation (16) becomes:

$$P(I) = P(R|A_1)P(A_1) + P(R|A_2)P(A_2)(1 - P(A_1)) \qquad (17)$$

If the term $(1 - P(A_1))$ is small, then the second sensor is not a principal source of alarms and errors made in evaluating $P(R|A_2)$ may be ignored. Taking advantage of such conditions, the EASI method could be simplified as follows. For each sensor in the system,

where

$$E(t_{a_i}) \geq E(t_r), \text{ let } P(R|A_i) = 1 \qquad (18)$$

and where

$$E(t_{a_i}) < E(t_r), \text{ let } P(R|A_i) = 0. \qquad (19)$$

This modification (which could be called the Very EASI method) then consists of simply calculating the cumulative probability of alarm along the adversary's path from the starting point (usually the plant boundary) up to a point which is the security force's expected response time from the terminal point. Actually, this method would yield correct results if no sensors satisfied condition (12) along the path being analyzed. However, this simplification may satisfy most preliminary evaluations of security system designs provided the limitations of the method were well understood.

APPENDIX B

GLOSSARY OF SELECTED SAFEGUARDS TERMS

ADVERSARY: An individual or an organized group intending to cause adverse societal consequences through acts involving nuclear material.

ADVERSARY ACTION SEQUENCE: An ordered set of specific acts, which if completed could produce an event of serious consequences to society.

ADVERSARY PATH: Any physical route which could be taken by the adversary in order to perform the adversary action sequence.

ADVERSARY TASK: A specific function which must be performed by the adversary in order to proceed along a path; i.e., penetrate a barrier, travel through a given distance, etc.

ADVERSARY SEQUENCE INTERRUPTION: The act of breaking in upon the adversary action sequence by the response.

RESPONSE: A counteraction taken by the physical protection system against the adversary.

PHYSICAL PROTECTION: A safeguards subsystem directed against adversary actions at or within protected boundaries through the functions of detection, assessment, communications, delay and neutralization.

DETECTION: The discovery of any adversary action.

ASSESSMENT: The verification that an adversary action has been sensed and the determination of the proper response required.

COMMUNICATIONS: The act of informing either the local physical protection response forces, or the local law enforcement agency or both of an adversary action.

DELAY: A means to impede adversary progress - usually to buy time to effect a response.

NEUTRALIZE: To render an adversary ineffective — no longer able to complete the action sequence. Usually the result of a successful response.

APPENDIX C

BARRIER PENETRATION TEST DATA

The purpose of this Appendix is to provide data over a range of barriers which would enable the user to make reasonable estimates of penetration times for specific barriers and penetration methods. The data were obtained from the Barrier Penetration Data Bank being compiled at Sandia Laboratories for the purpose of producing a barrier penetration handbook in the near future. These data are currently not endorsed by NRC. Actual test times are given along with an estimate of the range of penetration times. Where data references are not specifically given, the data were obtained from tests conducted at Sandia Laboratories.

The penetration times given pertain to the set of tools used for that test. This does not mean that those tools necessarily provide the minimum penetration time for the barrier tested. It is generally agreed, however, that hand and power tools are capable of providing minimum penetration times for concrete walls less than 8 inches thick while high explosives are required for minimum penetration times for concrete walls 8 inches thick or greater. Penetration times for industrial sheet metal doors are considered to be in the range of 1 to 3 minutes with a mean of 2 minutes, with either tools or Jet-Ax explosives.

Locked doors may be penetrated by picking the lock. The time required to pick a standard straight-pin-tumbler design lock of good quality is in the range of 1 to 5 minutes with a mean of 3 minutes. Specially designed locks are available which can increase the above times by an order of magnitude.

Table C.1 provides test data on three types of barriers (fences, doors and walls) and specifies the type of barrier material, the number of people (adversaries) involved, equipment used (both manual and power), weight of equipment, penetration time, range of times, comments, and references.

An extensive source of data references can be found in "An Assessment of Some Safeguards Evaluation Techniques," NUREG-0141, R&D Associates, February 1977, Appendix C.

Table C.1 Barrier Test Data

		THREAT									
Barrier	Material	Number of People	Equipment	Manual Equipment Weight (pounds)	Power Equipment Weight (pounds)	Explosive Weight (pounds)	Total Weight (pounds)	Penetration Time (minutes)	Estimated Range of Time (minutes)	Comments	Reference
Fence	Chain link mesh, 9 gauge, 2 inch mesh, 7 feet high, with outriggers	2	Plank, 2 to 4 inches thick	20	-	-	20	0.10	0.09 to 0.11	Lift fabric and crawl under	NBSTN-837*
		1	Bolt cutter, 24 inches long	7	-	-	7	0.32	0.20 to 0.40	Cut triangular flap, 26 by 18 inches	NBSTN-837
		1	Gloves	0.5	-	-	0.5	0.10	0.05 to 0.15	Climb over at gate	NBSTN-837
GSA Class 6 Vault Door	0.375-inch-thick hard drill-resistance steel, 0.5-inch-thick stainless steel cover over bolt works	3	Hammer; punch; chisel; cutting torch, oxygen fed, electric arc; generator 3kW, gas operated	10	225	-	235	18.27	14.27 to 22.27	Expose bolt works with torch, force bolt, open door	NBSIR-73-223**
		2	Rocket torch	-	200	-	200	9.5	8.5 to 10.5	Cut 11-inch diameter hole through door	NBSIR-73-223
Door	0.75-in-thick steel plate, 3-in-thick fiberglas, 0.125-in-thick steel plate	1	Oxygen-lance, small tank, gauge, 2 bars	-	100	-	100	10.0	7.2 to 12.3	Cut 2 by 2-foot hole	------------

*National Bureau of Standards Technical Note
**National Bureau of Standards Internal Report

Table C.1 Barrier Test Data (Continued)

		THREAT									
Barrier	Material	Number of People	Equipment	Manual Equipment Weight (pounds)	Power Equipment Weight (pounds)	Explosive Weight (pounds)	Total Weight (pounds)	Penetration Time (minutes)	Estimated Range of Time (minutes)	Comments	Reference
Wall	Hollow cinder block; no. 5 rebar, 14 inches on center; cores filled with mortar	1	Sledge, 24-in bolt cutter	19	-	-	19	1.52	1.3 to 1.7	Hammer out hole, cut reinforcement material, 12 by 8-inch hole	NBSIR-73-223
Wall	Concrete 4 inches thick with no. 5 rebar, 5 inches on center	1	Sledge, cutting torch with tanks, Mapp	10	55	-	65	4.3	3.5 to 5.1	Beat hole in wall with 90 blows, cut rebar, 11 by 14-inch hole	NBSIR-73-101
		1	Sledge; cutting torch with oxyacetylene; explosive, linear shaped charge, Jet-Ax, JA-3, 5.6 ounces, 250 grains per foot	26.75	55	0.25	82	4.2	3.4 to 5.0	Fire Jet-Ax, hammer out opening, cut rebar, 24 by 31-inch hole	NBSIR-73-101
Wall	Concrete 8 inches thick with no. 5 rebar, 5 inches on center	2	Sledge; punch; 24-in bolt cutter; roto-hammer; drill; generator, 3kW, gas operated; explosive, linear shaped charge, Jet-Ax, JA-4, 5.6 oz, 550 grains per foot	56.1	90	0.4	146.5	5.1	4.3 to 5.9	Spall with Jet-Ax, drill 2 holes, punch out, 102 blows with sledge	NBSIR-74-528

Table C.1 Barrier Test Data (Continued)

		THREAT									
Barrier	Material	Number of People	Equipment	Manual Equipment Weight (pounds)	Power Equipment Weight (pounds)	Explosive Weight (pounds)	Total Weight (pounds)	Penetration Time (minutes)	Estimated Range of Time (minutes)	Comments	Reference
Wall	Concrete 8 inches thick with no. 5 rebar, 5 inches on center	2	Sledge; punch; chisel; rotohammer; drill; cutting torch with tanks, oxyacetylene; generator, 3kW, gas operated	13.0	130	-	143	14.1	13.7 to 14.5	Drill 20, 0.75-in diameter holes, spall, chisel, hammer out, cut rebar, 8 by 12-inch hole	NBSIR-73-101
Wall (Vertical Steelcrete)	Concrete 12 inches thick with no. 1 gauge Wheeling expanded steel mesh laced with rebar	1	Sledge; explosive, satchel charge	6	-	20	26	5	3 to 7	Air coupled charge layed on wall, blast out 12-inch-diameter hole, entry possible, exit not possible, beat rebar back, 20-inch-diameter hole	SLA, Div 1752

APPENDIX D

INTRUSION DETECTION SYSTEMS INFORMATION[1]

The performance of any detection system is highly dependent upon the system design (inherent performance), environmental effects (both natural and man made), and adversary attributes (skills and resources). Therefore, only within specific sets of conditions can detection system performance be quantitatively evaluated. For the near term, confident extrapolation of performance from one condition set to another appears limited due to only a rudimentary understanding of how site-specific installation variables, along with physical and environmental conditions can affect component performance. Recognizing the state of the art and the fact that some site-related conditions may be unknown to system designers, it is recommended that new installations be extensively tested to uncover and correct any problems.

The following information is given to acquaint the reader with potential problem areas in detection systems and to offer recommendations for improved performance.

1. SENSORS

A sensing device in combination with a processor forms the basic detection element. It is this combination that is commonly called a "sensor."

Sensors form the backbone of all detection systems, but current performance requirements challenge the state of the art. Two performance characteristics associated with sensors are:

Probability of Detection, which provides an indication of sensor performance in detecting an adversary within the zone covered by the sensor, and

False Alarm Rate,* which provides a measure of the expected rate at which alarms not attributable to adversary activity will occur.

---

*For the purpose of sensor evaluation *per se*, nonadversary-related alarms must be categorized as false alarms (reason unknown) and nuisance alarms (reason known). For the purposes of this handbook, both categories are included in the term "false alarm."

There is presently no single sensor that will reliably detect all intruders, yet have acceptably low false alarm rates in all expected natural and man-made environments associated with nuclear facilities. Although various types of sensing elements and processors have been devised in an attempt to cope with the wide range of anticipated environmental conditions, these attempts have been of limited success. Generally, improvements in detection have been accompanied by increased false alarm rates, while reductions in false alarm rates have resulted in a lowered detection capability. Table D.1 indicates characteristics of general types of exterior sensors.

The probability of detecting and correctly assessing adversary activity is based on the equipment capability, and is conditional on maintenance as well as security afforded the equipment. A safeguards system should be designed so that the probability of detection will be as near unity as possible consistent with practical equipment limitations. Using two or more systems, high detection probabilities appear achievable for most environments. Lower probabilities would have to be accepted during periods when only one system is operative.

False alarms are considered to be alarms not caused by valid adversary activity. The false alarm rate (FAR, given in units of alarms per hour) affects the expected assessment activity since, each time an alarm occurs, the assessment system must be employed. If there were no false alarms, the assessment system would be used only to determine adversary characteristics and direct response force actions. The acceptable FAR would depend heavily on the ability to identify the source of each alarm. If all alarm causes could be easily identified by the assessment system, then a fairly high rate might be acceptable. However, a high FAR will tend to undermine confidence in the system; for this reason, a system design goal should be to eliminate as many causes of false alarms as possible.

When using exterior sensors on the perimeter of an area or building, a well-defined clear zone or isolation zone is highly desirable. Such a zone results in a reduction of false alarm rates inadvertently caused by innocent people, large animals, blowing debris, etc. Also, the perimeter should be divided into segments, independently alarmed, in order to localize the area of an alarm. This provides the capability to rapidly assess an alarm; it likewise assists the response force operations.

Table D.1 Characteristics of Exterior Sensors

Application	Operating Principle	Availability	Detection					Conditions For Unreliable Detection	Typical Defeat Methods	False Alarm Rate in an Environment Free from Major Causes of False Alarms	Major Causes of False Alarms												
			Nonmagnetic	Walk, Run, and Crawl	Tunnel	Climb Fence	Cut Fence				High Winds	Heavy Rain	Heavy Snow	Heavy Fog	Insects	Birds	Small Animals	Large Animals	Seismic Activity	Thunder and Lightning	Electrical Transients	RFI	
Buried Line	Seismic-Magnetic	Military Production	X	X	X				Bridge and carry no ferromagnetic material	Low to medium	X							X	X	X	X	X	
	Seismic	Discontinued	X	X	X			Frozen ground	Bridge	Low to medium	X							X	X	X			
	Magnetic (some seismic sensitivity)	Production		X	X				Carry no ferromagnetic material	Very low										X	X	X	
Fence-Associated	Electret Cable	Production	X			X	X		Ladder or short tunnel	Very low	X							X		X	X		
	Tilt Switch	Production	X			X			Ladder or short tunnel	Very low to low	X							X					
Free-Standing Line	E-Field (can be fence-associated)	Limited Production	X	X		X	X	High grass	Tunnel	Very low to low						X	X	X		X	X	X	
	Microwave	Production	X	X				Irregular terrain, high grass, or snow drifts	Tunnel	Very low to low						X	X	X				X	
	Infrared	Production	X	X				Irregular terrain, high grass, or snow drifts	Ladder, short tunnel, or redirect low beam	Very low to low		X	X	X	X	X	X	X		X			
Point	Electromagnetic	Development	X	X					Tunnel	Insufficient data						X	X	X		X		X	

2. ASSESSMENT SYSTEMS

Direct visual assessment or closed-circuit-television (CCTV)-aided assessment of alarms is essential to prevent commitment of response forces as a result of false alarms or diversionary actions by intruders. Alarm sectors or zones should be limited to some length (exterior sensors are normally designed to cover a range of approximately 100 meters) that would facilitate rapid assessment. In addition, the alarm zones should be adequately lighted and free from clutter to aid in accurate assessment.

CCTV assessment systems can be manually employed or automatically employed following an alarm. The particular form of employment would depend on the amount of barrier delay time following an alarm. Automatic employment, triggered by the occurrence of an alarm, is generally preferred. Also, recording features can be associated with assessment systems, providing an "instant replay" capability for use by the assessing personnel.

3. INFORMATION DISPLAY SYSTEMS

Information display systems normally have the capability to indicate an alarm state, provide a chronological log of alarm occurrences, and display the assessment information. The exact capabilities associated with an information display system are dependent on the complexity of the overall sensor and assessment system. The information display system should be located in a secure and hardened room to protect it and the monitor personnel from attack. If the primary response force is not located in close proximity to the protected area, consideration should be given to providing a duplicate information display system in the response force operation center. Two information display systems should be provided in separate protected locations to protect against a single insider, acting malevolently or under duress, from ignoring an alarm or disabling the equipment.

4. SIGNAL COMMUNICATION NETWORKS

Signals must be transmitted from remote sensors to some central location where the information can be displayed to security personnel. Both hardware transmission lines and radio frequency (rf) transmission have been used for this purpose. To preclude defeat by remote rf jamming, hardwire transmission lines generally are preferred for fixed sites. In some situations, transmission lines are located entirely within a protected area, while in others they must be located partly outside the protected area. In either case, the lines are vulnerable to adversary actions. Even lines inside a protected area could be attacked by persons with authorized access who, for example, are acting under duress. Consequently, some continuous-line supervisory technique should be used not only to detect tampering that could compromise the detection systems but also to verify line integrity.

Line supervisory techniques vary from relatively simple systems that monitor line current, through more complex tone superposition systems, to pseudorandom or random digital coding systems. Sensors and assessment systems must be compatible with whichever supervision method is used for a particular security installation. The most common supervisory technique in use today is the simple system that monitors line current through the use of a known voltage located at the control console, coupled with a passive termination located at the sensor. Systems of this type can be compromised since even a complex, passive termination can be measured and a duplicate produced to bridge the line; however, such systems do provide a certain level of protection against adversary activity, as well as an indication of inadvertent severance of the communication link.

Regardless of the complexity of the line supervision system used, such a system can be defeated with a probability of near unity if the adversary is allowed access to the line for sufficient time and if the adversary has adequate resources and technical expertise. Consequently, the line must be protected by either security patrols or tamper sensors in order to detect attempts to gain access to the line. Line access delay times must be compatible either with the patrol interval or with response times following a tamper alarm.

5. TAMPER PROTECTION

Detection systems must be protected from tampering so that their effectiveness cannot be compromised. Some sensors are self-protecting in that any attempt to approach the sensor would cause an alarm. Obviously, this is a most desirable condition. However, many sensors are not self-protecting, and even self-protecting sensors can be defeated by knowledgeable adversaries if access to the equipment is allowed. For this reason, all equipment should be in tamper-resistant enclosures which are protected by switches or self-protective devices that will detect tampering and generate an alarm signal. These antitamper circuits must be in operation even when the protected equipment is in an access mode; bypass should be allowed only for authorized, supervised maintenance or operational procedures.

6. POWER

Each detection system, including the assessment element, should be capable of operating from commercial AC power. Provisions should be made for automatic switchover to emergency power (and back to commercial power) without causing an alarm in the event of commercial power failure. A signal should alert security forces to the fact that the system is operating on emergency power. Emergency power supplies should be protected from tampering in a manner similar to other system elements. Emergency power may be supplied by uninterruptible power sources, by batteries combined with automatic-starting generators, or by batteries alone.

7. PERIODIC PERFORMANCE VERIFICATION

Periodic testing of sensors and assessment devices is essential to assure continuous, proper functioning and to detect equipment failures before they compromise the security system. Few available systems have complete self-test features. Typically, processor performance is tested, but the sensing device is not. For example, the seismic buried-line sensor self-test feature directly excites the pressure transducers which are the sensing elements. If the ground is frozen, detection will be unreliable, but the self-test will still indicate that the processor is working and that the transducers are intact. In general, passive systems are limited to this sort of self-test, and a complete test can only be accomplished by controlled penetration of the isolation zone at selected places.

Active systems can be completely tested by varying or modulating the transmitter signal. Such a feature should be incorporated in active systems if possible.

Obviously, a complete, continuous, automatic self-test feature is desirable so that the long periods of uncertainty between controlled penetrations (as well as the manpower requirements for such tests) could be avoided. With this feature, failure or malfunction of the system would be recognized immediately and remedial action initiated or alternative procedures implemented in a timely manner.

APPENDIX E

EASI PROGRAM LISTING FOR SR-52

Display	Key	Display	Key	Display	Key
00 46	*LBL	37 46	*LBL	73 23	lnx
01 15	E	38 13	C	74 53	(
02 47	*CMS	39 65	X	75 42	STO
03 25	CLR	40 43	RCL	76 00	0
04 81	HLT	41 00	0	77 06	6
05 46	*LBL	42 03	3	78 55	÷
06 11	A	43 95	=	79 53	(
07 44	SUM	44 42	STO	80 01	1
08 00	0	45 00	0	81 85	+
09 01	1	46 04	4	82 43	RCL
10 81	HLT	47 43	RCL	83 00	0
11 46	*LBL	48 00	0	84 06	6
12 12	B	49 07	7	85 54	)
13 40	*X^2	50 85	+	86 54	)
14 44	SUM	51 43	RCL	87 65	X
15 00	0	52 00	0	88 43	RCL
16 02	2	53 02	2	89 00	0
17 81	HLT	54 95	=	90 04	4
18 46	*LBL	55 30	*$\sqrt{X}$	91 95	=
19 18	*C´	56 20	*1/X	92 85	+
20 42	STO	57 65	X	93 43	RCL
21 00	0	58 53	(	94 00	0
22 03	3	59 43	RCL	95 08	8
23 81	HLT	60 00	0	96 65	X
24 46	*LBL	61 01	1	97 53	(
25 16	*A´	62 75	-	98 01	1
26 42	STO	63 43	RCL	99 75	-
27 00	0	64 00	0	100 43	RCL
28 05	5	65 05	5	101 00	0
29 81	HLT	66 54	)	102 04	4
30 46	*LBL	67 65	X	103 54	)
31 17	*B´	68 01	1	104 95	=
32 40	*X^2	69 93	.	105 42	STO
33 42	STO	70 07	7	106 00	0
34 00	0	71 95	=	107 08	8
35 07	7	72 22	INV	108 81	HLT
36 81	HLT				

---

*Denotes 2nd function key.

APPENDIX F

EASI PROGRAM LISTING FOR HP-67[3]

Display	Key	Display	Key
001 31 25 11	fLBL A	026 35 52	hx↔y
002 31 43	fCLREG	027 81	÷
003 33 01	STO1	028 01	1
004 35 53	hR↓	029 83	•
005 32 54	gx^2	030 07	7
006 33 03	STO3	031 71	x
007 35 53	hR↓	032 32 52	ge^x
008 42	CHS	033 33 05	STO5
009 33 04	STO4	034 01	1
010 35 22	hRTN	035 61	+
011 31 25 12	fLBLB	036 34 05	RCL5
012 35 54	hR↑	037 35 52	hx↔y
013 35 54	hR↑	038 81	÷
014 33 61 04	STO+4	039 35 52	hx↔y
015 35 54	hR↑	040 71	x
016 32 54	gx^2	041 35 82	hLSTx
017 33 61 03	STO+3	042 01	1
018 35 54	hR↑	043 51	-
019 31 51	f x=o	044 34 02	RCL2
020 22 13	GTO C	045 71	x
021 34 01	RCL 1	046 51	-
022 71	x	047 33 02	STO2
023 34 03	RCL3	048 31 25 13	fLBLC
024 31 54	f$\sqrt{x}$	049 34 02	RCL2
025 34 04	RCL4	050 35 22	hRTN

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Safeguards Network Analysis Procedure (SNAP) - Overview

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for the
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Abstract

Nuclear safeguards systems provide physical protection and control of nuclear materials. The Safeguards Network Analysis Procedure (SNAP)* provides a convenient and standard analysis methodology for the evaluation of physical protection system effectiveness. This is achieved through a standard set of symbols which characterize the various elements of safeguards systems and an analysis program to execute simulation models built using the SNAP symbology. The outputs provided by the SNAP simulation program supplements the safeguards analyst's evaluative capabilities and supports the evaluation of existing sites as well as alternative design possibilities. This paper describes the SNAP modeling technique and provides an example illustrating its use.

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*SNAP was developed for Sandia Laboratories by Pritsker and Associates, Inc., West Lafayette, Indiana.

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Safeguards Network Analysis Procedure (SNAP) - Overview

Introduction

The development of models to aid in the evaluation of physical protection systems of nuclear facilities began at Sandia Laboratories as early as 1974[1]. This work has been sponsored principally by the United States Nuclear Regulatory Commission. The purpose for developing these models is to construct techniques which can aid the physical protection system analyst. The goals of this systematic approach to evaluation are to provide:

1. A consistent approach to the evaluation of the effectiveness of physical protection systems in defending against a hypothesized adversary threat, and
2. A quantitative technique for determining upgrades to existent facilities and for designing new facilities.

The Safeguards Network Analysis Procedure (SNAP) developed through this research is a valuable technique which can be used by the physical protection system analyst in meeting these goals.

SNAP employs the network modeling approach to problem solving. By combining the SNAP symbology with knowledge of the system, specific scenarios, and modeling objectives, a network model of the system may be developed. Standardized procedures have been defined for describing the model in a data form acceptable to a computer program. The SNAP analysis program is used to simulate the system of interest. Reports are generated by the program to provide information which assists the analyst in evaluating the performance of proposed or existing safeguards system.

Experience gained from the early modeling attempts provided the impetus for the development of SNAP. Methodological completeness was a primary issue in the conceptualization of SNAP. This completeness has been argued for and interpreted in two quite distinct ways--producing the dichotomy macro- vs. micro-completeness. A safeguards methodology can be termed macro-complete if it can feasibly be used to evaluate effectiveness for all reasonable adversary scenarios. Alternatively, a micro-complete methodology is one in which safeguards effectiveness is evaluated for each individual scenario in sufficient detail to adequately represent all relevant considerations. With SNAP, the focus is on micro-completeness and the analyst is afforded the flexibility to model individual scenarios to virtually any level of detail that is deemed appropriate.

SNAP is conceptually appealing to the safeguards evaluator who has no previous experience with the use of models as well as to the professional modeler. This appeal is a result of the standard set of "safeguards symbols" which SNAP employs to characterize the various elements of the safeguards systems. These symbols enable the analyst to represent complex scenarios with a modest amount of effort. Once constructed, these symbolic representations translate directly into data for the SNAP computer program which, in turn, yields estimates for a variety of safeguards effectiveness measures.

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Modeling Philosophy

SNAP is a simulation language developed specifically for modeling safeguards systems[2]. With the SNAP approach, the analyst constructs a model of the safeguards system by interconnecting a set of SNAP symbols to represent the system elements and their interactions. The resulting SNAP networks are then translated to a computer compatible form by data cards representing the symbols and their interconnections.

Using the SNAP procedure for safeguards modeling, one combines knowledge of the system, scenarios, modeling objectives, and the SNAP symbology to develop a network model of the system under consideration. This network model is a graphic representation of the nuclear facility, guard operating policies, and adversary attack scenario. Typically, the elements of this network model will form a one-to-one correspondence with the components of the actual physical system and scenario being studied. Due to this relationship, a SNAP network provides an excellent communications vehicle. SNAP symbols have been designed to represent the individual elements of a nuclear safeguards system, thus the translation from a system element to the SNAP symbol should be direct.

A SNAP network model is composed of the facility subnetwork, the guard subnetwork, and the adversary subnetwork which interact to produce the overall behavior of the safeguards system. Items which flow through network models are referred to as transactions. The transactions which flow through a SNAP network are guard forces and adversary forces. The force is the most fundamental level of detail in SNAP and represents one or more individuals acting as a single unit.

The facility subnetwork is the most basic of the three networks. It is a static network in the sense that transactions do not flow through it during the simulation. Its purpose is to define the various elements of the facility and their relationships. These elements may include fences, yards, nuclear material, storage vaults, doorways, rooms, sensors, etc. The guard subnetwork defines guard operating policies and includes a representation of the guards' decision logic as well as their physical movement through the facility. Guard forces are the transactions which flow through the guard subnetwork. The adversary subnetwork is treated in a similar manner.

SNAP Symbology

The SNAP symbology is designed to form a one-to-one correspondence with the actual physical components and guard or adversary actions. That is, there is a set of symbols for modeling the facility of interest and for developing models of the adversary and guard force scenarios as they relate to that facility.

The procedure for modeling safeguards systems using the SNAP symbology is as follows: The analyst first builds the model for the facility that he wishes to study using the facility model symbology. Then, using the guard and adversary model symbologies, he constructs various scenarios. These scenarios, with the facility model, are simulated and information is generated to provide relative measures of system performance. Through this procedure, the analyst may evaluate various defender policies and facility design alternatives.

The SNAP symbology for the facility model is shown in Table I. The PORTAL, SPACE, BARRIER, and TARGET elements identify actual facility system components. Adjacency and Precedence branches define their interrelationships. Adversary Detection Devices (ADD) include sensors and monitors. The user identifies SNAP elements by alphanumeric labels. For example, the user specifies that a sensor label is associated with a certain node by entering the label for that sensor in the appropriate portion of the node (indicated by ADD in Table I).

Based on the model of the facility of interest, the user then builds models of the guard and adversary scenarios to be considered. These models are built using the guard and adversary symbology shown in Table II. Each of these elements relate directly to a particular activity of the force being modeled. For example, the process of an adversary crossing a fence is modeled using a TASK node. This node is tied directly to the facility model node which represents the fence by its alphanumeric label, as indicated by FLBL on the TASK node. Similar procedures hold for the other nodes.

A unique data card has been defined for each symbol in the three models. Information specified on the user's network is transferred directly to these data cards, which are processed by the analysis program. The simulation of the model is then executed by running the SNAP analysis program and output reports are automatically generated.

SNAP Application

In order to illustrate the use of the symbology and indicate the information available from the analysis the following example application is provided. This application illustrates the use of SNAP concepts and symbols to model systems concerned with protecting nuclear material from sabotage or theft.

A diagram of the exemplary nuclear storage facility to be used for this application is shown in Figure 1. A fence surrounds the storage building on all sides. For modeling purposes, the fence has been divided into two parts, fence 1 and fence 2. The space surrounding the storage building has also been divided into two parts, space 1 and space 2. There is a TV camera in space 2 monitoring that space. The TV camera functions as a sensor and will be referenced as sensor S3. A guard station which monitors all sensors on the site is located in space 1. The outside door is alarmed and may be entered from space 1. Space 3 contains the logic point L1 through which the signals from sensors S1, S2, and S3 must pass before reaching the monitor (M1) at the guard station. Disablement of logic point L1 would interrupt the flow of information from those sensors to the guard station monitor. An armoured door separates space 3 and the target, the nuclear material access area. The material access area is monitored by sensor S2, a motion detector.

Figure 2 illustrates the corresponding SNAP facility subnetwork. This figure has been labeled so as to make a one-to-one correspondence between the storage site schematic and the model. Note that there are two possible entrances by adversaries denoted by portal nodes E1 and E2. These are connected to two barrier nodes which represent fence 1 and fence 2. Paths that the adversary might take are easily determined for this model. Since adversary and guard forces may travel in either direction between the various facility components, only adjacency is indicated on the branches between the nodes in this model.

After the facility model is developed, the adversary and guard subnetworks are built in reference to that facility model. The guard subnetwork is shown in Figure 3. The guard force transaction enters (ENT) the guard subnetwork at time 0.0 and begins monitoring the three sensors (W1, W2, and W3).

Sensor S1 is the sensor on the alarmed outside door. If sensor S1 is triggered, the guard force takes two minutes to muster forces (DA1). A force of two members is allocated (A1) from base B1. The guard force then moves (MS11) into space 1 to assess the situation. If no adversaries are detected during the time the guards are on patrol, the guard force returns to base (RTB1) and resumes the monitoring of sensor S1. If adversaries are encountered, an engagement will ensue.

Sensor S2 represents the motion detector in the material access area. If sensor S2 is triggered, the guard force takes two minutes to muster forces (DA2). A force consisting of two members is then allocated (A2) from base B1. This force is the same force that is allocated if sensor S1 is triggered. The guard force then moves (MS12) into space 1 to search for adversaries. If adversaries are encountered, an engagement will ensue. If no adversaries are found, the guard force will wait (W4) at space 1 for an adversary force to arrive. If adversaries do arrive, an engagement will ensue. If the guards win, they return to base (RTB2) and begin monitoring sensors again.

Sensor S3 is the TV camera. If sensor S3 detects adversaries in space 2, the guard force musters (DA3) and allocates (A3) two guards from base B1. The force then enters space 1 (MS13) to search for adversaries. If none are found, the guard force moves into space 2 (MS2), continuing the search. After space 2 has been searched and if no adversaries have been found, the guards return to space 1 (MS14) to search again. If the guard force encounters an adversary force at any time during the searching of space 1 or space 2, an engagement will occur. If the guards win the engagement, they continue their search procedures to locate any other adversaries which may be present. After searching for adversaries in space 1 and space 2, the guards wait (W5) in space 1 for further instructions. If the guards encounter an adversary while they are waiting, an engagement will begin. If the guards win the engagement, they return to base (RTB3) and begin monitoring sensors again.

This summarizes the operating procedures which the guards will follow in this model. This guard subnetwork is typical of guard responses to adversary intrusion for the hypothetical facility under consideration.

The adversary force subnetwork is shown in Figure 4. The adversary's objective is to achieve a radiological release through sabotage of the nuclear material in space NM by using an explosive device. The adversaries enter (ENT1) at time 0.0 and immediately penetrate fence 1 (CF1). Next, they cross space 1 (CSP1) and divide their force in half. Half of the force moves into space 2 (CSP2) as a diversion. They wait in space 2 until the other half of their force joins them. The other half begins penetration of the alarmed outside door. Fifty percent of the time they will disable sensor S1 and not be detected (DOD or DODN). After penetrating the outside doors, this adversary force crosses space 3 (CSP3) and penenetrates the armoured door (DAD). They then sabotage the nuclear material (SMN) by leaving an explosive device and retrace their steps through the armoured door (EAD), across space 3 (ESP3) and through the outside door (EOD), and into space 1 (ESP1). They cross space 1 and move into space 2 (ESP2) where they join with the other adversary force (WS2A). When both adversary forces are in space 2, they join and penetrate fence 2 (CF2), exiting the facility (EX2). Since the adversary objective is sabotage, the adversaries do not have to exit the network to be successful.

Figure 5 shows a portion of the trace generated from a simulation run of this model. The guard force enters and begins monitoring the sensors. From this trace, an event-by-event account of one realization of the network can be obtained. The information on this trace relates directly to the networks defined by the user.

This model was simulated 500 times to generate statistics. The results of these simulations are shown in Table III. From these results, the user can obtain information concerning the behavior of the system. The overall performance measure, the probability the adversary achieves his objective, was observed to be 0.13. That is, in this example, the adversary was successful in penetrating sabotage on 13 percent of the attempts. This would most likely be viewed as an unacceptable level of performance and indicate that revisions to the facility or guard operating policies are warranted. Other performance measures are available as indicated.

Commentary

The Safeguards Network Analysis Procedure provides analysts with a technique for modeling and evaluating various safeguards system design alternatives. The SNAP symbology also provides analysts with a vehicle for communication, thereby enhancing the model building process. The technique is easy to use and is currently being used in the analysis of real-world nuclear facilities.

It should be emphasized that the physical protection analyst should remain intimately involved with the analysis at every stage. Due to the complexity of physical protection problems, information gained by exercising SNAP, is intended to be of a supplementary nature only. That is, the analyst should consider the outputs of SNAP as inputs to the holistic evaluative process.

References

1. Chapman, L. D., et.al, "Safeguards Methodology Development History," Proceedings of the 1st Annual Symposium on Safeguards and Nuclear Material Management, April 1979.

2. Grant, F. H., Miner, R. J., and Engi, D., "A Network Modeling and Analysis Technique for the Evaluation of Nuclear Safeguards Effectiveness," SAND78-0671, Sandia Laboratories, Albuquerque, NM, December 1978.

TABLE I

Facility Model Symbology

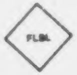
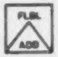
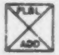
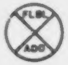
PORTAL		System Entrance Point
SPACE		Space in Facility
BARRIER		Barrier in Facility
TARGET		Adversary Objective
ADD	data card	Adversary Detection Devices
Adjacency	——	
and		
Precedence	——→	

TABLE II

Guard and Adversary Model Symbology

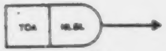
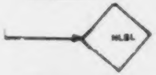
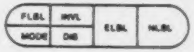
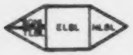
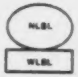
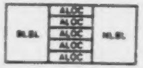
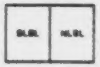
ENTER		Enter System
EXIT		Exit System
TASK	 FLBL INVL MODE DIS ELBL NLBL	Perform Task
WAIT		Wait for Signal or Triggering Condition
SIGNAL		Signal WAIT Node
ALLOCATE	 BLBL ALOC ALOC ALOC ALOC ALOC NLBL	Allocate Guard Resources
RTB		Return Resources to Base
BASE	data card	Define Base Characteristics
OBJECTIVE	data card	Define Adversary Objective
REINFORCEMENT	data card	Specify Reinforcement Force Characteristics
ENGAGEMENT	data card	Specify Engagement Parameters
BRANCHING	REG. SPLIT ——→	Regular
	PRO. PRB. SPLIT ——→	Probabilistic
	DEC. CONDITION SPLIT ——→	Decision

TABLE III

Performance Measures

Average Number of Engagements Per Run	1.97
Average Number of Engagements Won by Guards Per Run	1.42
Average Number of Engagements Won by Adversaries Per Run	0.55
Probability Adversary Achieves Objective	0.13
Number of Guard Casualties Per Run	2.42
Number of Adversary Casualties Per Run	3.00
Time for Engagement	5.51 min.
Total Engagement Time Per Run	10.87 min.
Number of Engagements Per Run	1.97
Time Between Adversary Entrance and First Engagement	3.29 min.
Scenario Simulation Time	16.21 min.
Scenario Simulation Time Given Adversary Succeeds	39.43 min.
Scenario Simulation Time Given Adversary Fails	12.58 min.

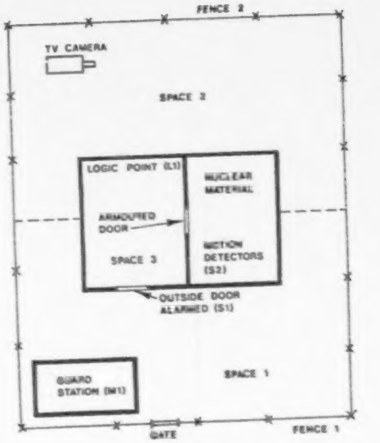

FENCE 2
TV CAMERA
SPACE 2
LOGIC POINT (L1)
NUCLEAR MATERIAL
ARMOURED DOOR
SPACE 3
MOTION DETECTORS (S2)
OUTSIDE DOOR ALARMED (S1)
GUARD STATION (M1)
SPACE 1
GATE
FENCE 1

Figure 1. **Exemplary Facility Schematic**

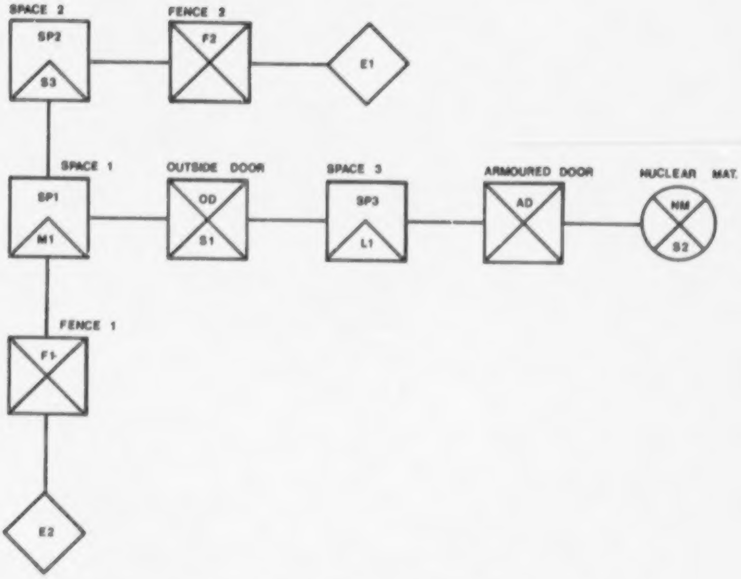

SPACE 2
SP2
S3
FENCE 2
F2
E1
SPACE 1
SP1
M1
OUTSIDE DOOR
OD
S1
SPACE 3
SP3
L1
ARMOURED DOOR
AD
NUCLEAR MAT.
NM
S2
FENCE 1
F1
E2

Figure 2. SNAP Model of the Exemplary Facility

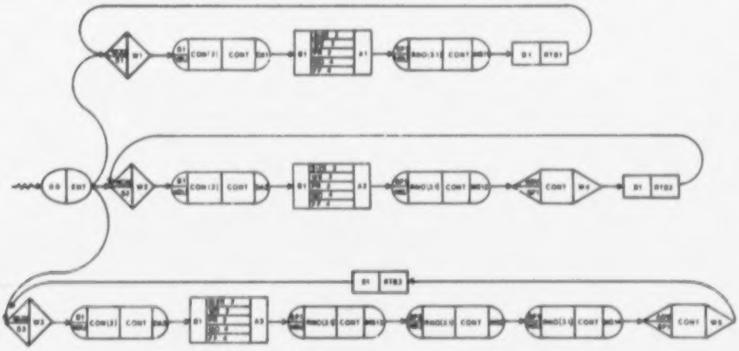


Figure 3. Guard Force Scenario Network

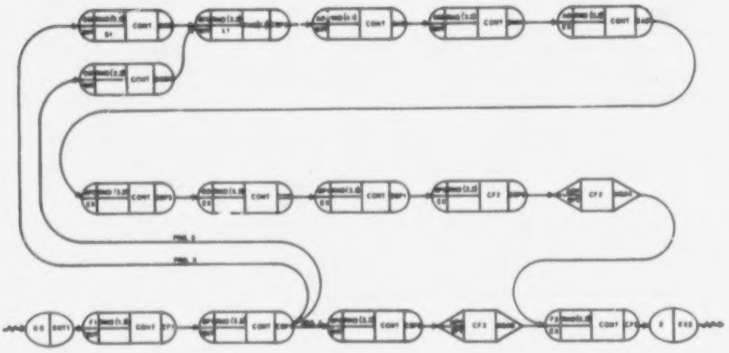


Figure 4. Adversary Force Scenario Network

```
                              ****************
                              *              *
                              *    TRACE     *
                              *   RUN NO  1  *
                              *              *
                              ****************

*************************************************************************************************************
* FORCE  *  NODE  *           EVENT           * FACILITY*          FORCE ATTRIBUTES          * SENSOR * ASSOC. *  TIME  *
*        *  LABEL *                           *   NODE  *------------------------------------* LABEL  *  NODE  *        *
*        *        *                           *         * SIZE   WE     PR     FF     MD     *        *  LABEL *        *
*        *        *                           *         *                                    *        *        *        *
*************************************************************************************************************

 GUARD  1   ENT     ENTER                                  0      0      0      0      0                           0
 GUARD  1   ENT          BRANCHED                          0      0      0      0      0              W1           0
 GUARD  2   ENT          BRANCHED                          0      0      0      0      0              W2           0
 GUARD  3   ENT          BRANCHED                          0      0      0      0      0              W3           0

 GUARD  1   W1      MONITOR SENSOR                         0      0      0      0      0    S1                     0

 GUARD  2   W2      MONITOR SENSOR                         0      0      0      0      0    S2                     0

 GUARD  3   W3      MONITOR SENSOR                         0      0      0      0      0    S3                     0

 ADVER  1   ENT1    ENTER                      F1          4.   8.00   8.00   8.00   8.00                           0
 ADVER  1   ENT1         BRANCHED              F1          4.   8.00   8.00   8.00   8.00              CF1          0

 ADVER  1   CF1     START OF TASK              F1          4.   8.00   8.00   8.00   8.00                           0

 ADVER  1   CF1     END OF TASK                F1          4.   8.00   8.00   8.00   8.00                         .06
 ADVER  1   CF1          BRANCHED              F1          4.   8.00   8.00   8.00   8.00              CSP1       .06

 ADVER  1   CSP1    START OF TASK              SP1         4.   8.00   8.00   8.00   8.00                         .06

 ADVER  1   CSP1    END OF TASK                SP1         4.   8.00   8.00   8.00   8.00                        1.42
 ADVER  1   CSP1         BRANCHED              SP1         2.   4.00   4.00   4.00   4.00              DOBM       1.42
 ADVER  2   CSP1         BRANCHED              SP1         2.   4.00   4.00   4.00   4.00              CSP2       1.42

 ADVER  1   DOBM    START OF TASK              OB          2.   4.00   4.00   4.00   4.00                        1.42
 ADVER  1   DOBM         TRIGGERED SENSOR      OB          2.   4.00   4.00   4.00   4.00    S1                  1.42

 GUARD  1   W1      WAIT NODE TRIGGERED                    0      0      0      0      0                         1.42
 GUARD  1   W1           BRANCHED                          0      0      0      0      0              BA1        1.42

 GUARD  1   BA1     START OF TASK              B1          0      0      0      0      0                         1.42
```

Figure 5. Simulation Trace Excerpt

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APPLICATION OF SAFE TO AN OPERATING REACTOR*

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3,4

Abstract

A method for the evaluation of physical protection systems at nuclear facilities has been developed. The evaluation process consists of five major phases: (1) Facility Characterization, (2) Facility Representation, (3) Component Performance, (4) Adversary Path Analysis, and (5) Effectiveness Evaluation. Each of these phases will be described in some detail and illustrated by examples. The process for evaluation of physical protection system effectiveness against an outside threat will be presented for a reactor facility.

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APPLICATION OF SAFE TO AN OPERATING REACTOR

Introduction

A procedure for evaluating physical protection systems at nuclear facilities, through the use of the Safeguards Automated Facility Evaluation (SAFE) methodology and a technique for target identification for light water reactors (LWRs) is described in this paper.

The SAFE methodology can be applied to one of two adversary goals, an adversary goal of either theft or sabotage. Within each adversary goal, a further decomposition into adversary action categories appears necessary. For an analysis of an adversary whose goal is theft, the adversary action categories of access, acquisition, and removal must be considered. For example, if an outsider were trying to gain access to the material within a nuclear facility, the access phase of the adversary actions would be the travel of the adversary from the facility boundary up to the material location. The next phase would be the acquisition phase, which is the actual acquiring of the material by the adversary. This might involve gathering the material and placing it in a container preparatory to its removal. The final adversary action category is the removal phase, i.e., the actual transport of the material by the adversary from inside the facility to beyond the facility boundary.

A similar set of adversary action categories can be applied to the adversary goal of sabotage except that in this case, it is not necessary for the adversary to escape from the facility to achieve his goal. The adversary must first gain access to the vital components of the facility and then destroy vital components. If the adversary is successful in destroying the vital components, it is assumed that his sabotage mission would be successful even though he may not escape from the facility. These adversary action categories represent a decomposition of the analysis so that a comcomphensive evaluation of the physical protection system can be determined.

Figure 1 shows the physical protection evaluation process broken down into five different areas: (1) facility characterization, (2) facility representation, (3) component performance, (4) adversary path analysis, and (5) effectiveness evaluation. Any comprehensive evaluation technique must consider these areas in some level of detail. The first step in the evaluation process is begun by completion of the facility characterization phase. A primary concern in this phase is target identification. The facility characterization phase is an input to the SAFE methodology. The second step in the evaluation process converts a plant layout (blueprints) into a computerized facility representation. The third step requires the analyst to set the component performance of the physical protection system based on those adversary characteristics which are of concern. The fourth step involves the generation of critical adversary paths to each target. The final step in the process, effectiveness evaluation, provides a more detailed analysis of the critical adversary paths. For a comprehensive analysis, the analyst must select and evaluate several alternate paths, different environmental and adversary conditions or threats, and different targets that might represent different operational conditions (i.e., in a maintenance mode of a nuclear reactor, the facility might be configured quite differently than it is in a normal operation mode and possess a different set of targets). If the analyst were designing a facility, he would actually repeat the entire process from the beginning and consider changes to the facility. To perform a comprehensive analysis, the analyst would have to cycle through each of these loops several times, looking at different paths and different environmental conditions that were relevant to the specific site and different threat characteristics. Each of the five areas which comprise the physical protection evaluation process is discussed briefly in the following sections of this paper.

Facility Characterization

The first step in the evaluation process is the facility characterization phase. The objective of this phase is to determine six essential facility characteristics: (1) the plant layout characteristics, (2) the targets and vital areas, (3) the operational conditions, which include such items as maintenance condition, normal operation and emergency condition, (4) the environmental conditions that are relevant to the specific site, i.e., heavy rain, snow, or extreme cold, (5) identification of the components of the physical protection system and their location, and (6) the characteristics of the guard forces which include number of guards, types of weapons, routing of patrols, etc. The facility characterization process is illustrated in Figure 2. The inputs to the facility characterization process include the various security plans that have been developed by the facility, the facility drawing, the safety analysis report, and the environmental reports for the facility. This information should be supplemented with information gained from site visits as required.

An essential output of the facility characterization phase is the various plant layout characteristics, including the barriers, access points, etc. The targets and vital areas are identified for specific reactor operational conditions. Three additional sets of information can be obtained from this process; specific site-relevant environmental conditions from the environmental reports, the physical protection system component description and locations, and the particular guard characteristics which are available from the security plans.

One major output of the facility characterization phase involves the identification of targets and vital areas. Because the application of the method illustrated herein is a reactor, the primary concern is the identification and characterization of sabotage targets. A generalized vital area analysis procedure for LWRs has been developed and is shown in Figure 3. The generic sabotage fault trees (GSFT) can be converted to detailed site-specific sabotage fault trees by utilizing GSFT for LWRs and plant-specific data as input. A vital area analysis is then performed to determine the Type I and Type II vital areas. A Type I vital area is an area in which the adversary would be required to visit only one area in the facility in order to successfully compromise components that would lead to radiological sabotage. Type II areas are those areas in which the adversary would be required to visit more than one area in order to compromise components that would ultimately lead to radiological sabotage.

Vital area analysis has been applied to several different operating reactor facilities. The Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation has applied this process to roughly 13 pressurized water reactor (PWR) facilities and 13 boiling water reactor (BWR) facilities as part of their reactor review procedure.

Facility Representation

The second phase of the evaluation process is the facility representation phase. The objective of this phase is to provide a basis for the evaluation procedure through a computer representation of the facility layout. This phase provides an explicit record of the analyst's assumptions regarding the facility representation. As shown in Figure 4, the inputs to this phase are the outputs from the facility characterization phase, the plant layout characteristics, and the target and vital areas for specific operational conditions. The output of the facility representation phase is a specific computer representation of the facility. For example, a facility layout or blueprint, as shown in Figure 5, shows a chain-link fence around the outside of the facility and a main reactor building. In addition, there are several ancillary buildings around the area. All of this information is translated into a computer representation of the facility.

A procedure has been developed for accomplishing this task. The input required for this procedure includes the (1) plant layout characteristics that comprise the principal barriers and obstructions to any adversary movement, (2) all points of potential ingress and egress by the adversary (this might include such items as windows, doors, potential adversary penetration points of boundaries, barriers, fences, walls of the building, etc.), and (3) floor levels and their interconnection through stairwells and ventilation ducts. The specific targets and vital areas for a set of operational conditions is also required.

The facility representation phase is accomplished through a digitizing process pictorially illustrated in Figure 6, in which the analyst uses a digitizing tablet and a cross-hair pen to send X,Y coordinates of the locations from the blueprints to the computer. The analyst simply traces over the essential or key features of the blueprints and obtains a corresponding one-to-one computer graphics representation. The result of this process is a simplified facility drawing for the overall facility, as shown in Figure 7. This drawing represents the first level of the facility, i.e., the chain-link fence and the major buildings inside the fence. Figure 8 represents the interior of the building which is designated Plant Layout-Level 2. The diamonds represent potential sabotage targets, and the triangles represent stairwells that join one floor to another. Figure 9 represents the third level of this facility.

Component Performance

The next step in the process of evaluating physical protection systems involves setting the component performance of each of the physical protection system components. The objective of this phase is to base performance of both hardware and personnel upon relevant sets of environmental and adversary conditions for that specific site. As Figure 10 pictorially illustrates, the process involves as input the computer representation that was produced in the facility representation phase. Also, the facility characterization phase provides a description of the physical protection system components and the site-relevant environmental conditions. When this information is coupled with specific adversary characteristics, a specific component performance can be determined that is relevant to the environment and the given threat being considered. For example, if one component of the physical protection system is a fence disturbance detection system (an intrusion detection system on the fence at the perimeter of the facility) under a high-wind condition, the fence would shake the sensor system and the net result would be a large number of false alarms. Under this condition, the intrusion alarm would be ineffective. Therefore, it would be desirable to have alternative procedures or multiple detection systems in order to insure perimeter intrusion detection over all the site-relevant environmental conditions for that specific component. It is through the use of these types of component performance assignments that the analyst can set specific bounds on component performance while directly coupling this information to adversary attributes and environmental conditions. A worst-case component performance can be considered in terms of how the adversary can defeat the system and from this information bounds on adversary attributes can be set.

For this application of SAFE, the threat goal was sabotage by a single outsider under normal reactor operating conditions and the environmental condition of high winds. The adversary is on foot and equipped with hand tools for breaking and entering.

In summary, the component performance phase provides a method to document and communicate all of the analyst's input data assumptions. It also provides the basis for the effectiveness evaluation. Component performance is based on a specific set of operational, environmental, and adversary conditions. By providing bounds on specific adversary attributes, the analyst is not required to consider every scenario but, in a more global sense, a bound for the worst-case adversary scenarios is determined.

Adversary Path Analysis

The next phase in the evaluation process is the adversary path analysis phase. The objective of this phase is to provide a systematic procedure for generating meaningful adversary paths for subsequent evaluation.

The adversary path analysis process is shown in Figure 11 where the input from the component performance evaluation is a specific facility representation in terms of the digitized facility The facility and physical protection system are represented by a graph of nodes and arcs. The guard characteristics that are available for the interruption capability are obtained from the facility characterization phase. Interruption implies detecting the adversary with sufficient time to respond with a guard force to confront the adversary prior to his completion of the sabotage mission. It includes such items as the response time of the guards and weapons characteristics.

Critical adversary paths are generated to each target based on certain adversary characteristics. This permits an upper bound to be placed on the system performance given the adversary characteristics. The output is a critical set of paths for each target within the facility. Figures 12 and 13 illustrate this output on the digitized facility layout. The nodes (diamonds, squares, triangles) on the chain-link fence at the perimeter of the facility represent possible entrance points where the adversary could penetrate the fence.

The nodes on the building represent points where the adversary could enter through a door or penetrate a wall barrier. Each of the nodes will have assigned a time for penetration by the adversary and a detection probability if there is a detection mechanism at that particular location. The problem is then solved using a graph of nodes and arcs to find the most critical path to each target within the facility. Figures 12 and 13 illustrate one path in which the adversary comes through the chain-link fence, traverses the open area, and enters a building door. The adversary then goes inside the building, through a stairdoor, and down the hall through two more doorways to a target. This case represents a shortest path which the adversary could traverse to sabotage the facility.

The pathfinding algorithms used to identify critical paths provide a capability for examination of several alternative adversary strategies. The analyst can consider an adversary who tries to minimize his time with these pathfinding routines. This represents a force scenario being used by an adversary who penetrates barriers as rapidly as possible to strike the target. The user can also choose to determine the most critical paths to each target in terms of lowest probability of detection for the adversary. This represents a stealth or deceit tactic being employed by the adversary. The combination of these two measures in terms of minimum timely detection provides a more complete measure. In this case, the concern is with detecting the adversary and coupling that detection with sufficient delay time to permit the guard force to respond and confront the adversary before he has accomplished his mission. In essence, concern centers on an adversary trying to minimize detection up to a "guard response time locus" about the target. Within this response time locus, the adversary tries to minimize his time. This represents a critical adversary path which combines adversary tactics of force, stealth, and deceit.

In summary, the adversary path analysis forms a basis for bounding the adversary strategies and actions. It reduces the enormous numbers of adversary paths in a complex, multilevel facility to a manageable set for evaluation. Only the critical paths are generated to each target. If every possible path to a target in the facility being considered were exhaustively generated, it has been estimated that the number of unique paths exceeds 10^{30}. Even with currently available computers, it is very impractical to take an exhaustive search approach to this problem; therefore, very efficient algorithms have been created to find only the critical paths to each of these targets. In a matter of a few seconds of computer time, critical paths can be generated to 30 or 40 targets within a complex facility.

Effectiveness Evaluation

The last phase of the evaluation process is the effectiveness evaluation. The objective in this phase is to provide meaningful aggregate measures of physical protection performance. Inputs to the effectiveness evaluation are primarily obtained from the adversary path analysis phase and involve critical paths to each target within the facility. As noted in Figure 14, the characteristics of the guard force which involve the neutralization capabilities (the specific types of weapons, numbers of people, training, whether or not they have cover, etc.) are obtained from the facility characterization phase.

As an illustrative output of this process, part of the global results that were obtained from the facility is shown in Figure 15. All Type I targets have been considered. A response time of 7 minutes to each target has been assumed for three guards, and the targets have been numbered in Column 1 as Target 221, 440, etc. A vulnerability index has also been calculated. It indicates which of these targets is the most attractive in terms of the adversary trying to reach each of the targets conditioned by the performance measure being used in the critical path analysis. For example, in terms of minimum timely detection performance, Target 221 was generated 68 percent of the time by PATHfinding Simulation[2] (PATHS). It is the most attractive target that the adversary could choose in trying to achieve his objective. The interruption lower bound as determined by PATHS is shown to be 0.87 and increases in a manner very similar to the decreasing vulnerability index. In the neutralization process, it was assumed that three guards were available to fight one adversary. A simple product of interruption and neutral ization provides an an overall system win of 0.8 is obtained for target 221, while the system win for Target 440 would be 0.87. A worst-case condition for each Type I target within a facility is obtained and the analyst can insure that no targets possess a capability of less than 0.8 for the performance measures being utilized. Procedures also exist for the evaluation of all Type II targets within a nuclear facility.

Figure 16 is a three-dimensional picture of the probability of interruption plotted vertically versus the response time of the guard force versus the probability of detection of Sensor 2. (Sensor 2 is the door sensor located at the entrance to the reactor building as noted in Figures 12 and 13.) If the sensor fails or does not work properly, the probability of interruption deteriorates almost two to one, down to about 0.5; whereas,if the sensor is very effective, a very high probability of interruption is obtained, provided the response time is under about 5 or 6 minutes.

Summary

The physical protection system evaluation procedure is illustrated in Figure 17, which shows the computer techniques or codes on the left and the general outputs from each of the phases of the process on the right. Under facility characterization, a primary output is the target identification. Computer codes such as the Set Equation Transformation System[3] (SETS) and GSFTs are used to perform this analysis. To digitize the facility and prepare it for evaluation, several of computer codes, labeled here simply as Graphical Representation through Interactive Digitization (GRID) and Automated

Region Extraction Algorithm (AREA), are utilized. A digitized representation of the facility is obtained as an output. The component performance is then set from data obtained from the Safeguards Engineering and Analysis Data Base[4] (SEAD) which provides computer input to SAFE in terms of various delay times or detection probabilities. An output is obtained from SAFE to represent a specific facility in terms of specific environmental and operational conditions. The analyst then uses the adversary path analysis technique (PATHS, MINDPT, ADPATH[2,5,6]) to minimize detection probability, time, or timely detection and to generate critical paths for each target. EASI* and the Brief Adversary-Threat Loss-Estimator[7] (BATLE) are utilized for an effectiveness evaluation along the critical path that would provide the overall system performance measures. Ultimately the more critical adversary paths would require a more detailed evaluation using the Safeguards Network Analysis Procedure[8] (SNAP) to look at specific scenarios. This would provide additional detail in the overall system performance measure. The SAFE process can be accomplished in a matter of a few days to a few weeks. The vital area analysis within the facility characterization phase is currently being utilized by the NRC to identify Type I and Type II vital areas for all the operating reactors in the United States. Currently, the time to perform this process for a typical operating facility averages from 2 to 4 weeks.

In conclusion, a simplified and automated procedure for identifying targets and vital areas has been developed for BWRs and PWRs using the evaluation methods described. A mechanism for determining critical adversary paths which provide a determination of overall critical bounds on system performance in a global sense has been implemented. The process provides a very explicit documentation of all the analyst's assumptions. SAFE provides a basis for development and communication of policies and regulatory decisions relative to the physical protection system performance. From the licensee's perspective, the techniques could be utilized as a design aid to the licensee and for upgrading to meet certain regulations. SAFE has been applied to several facilities and should prove to a very useful technique for analyzing physical protection systems.

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*Estimate of Adversary Sequence Interruption

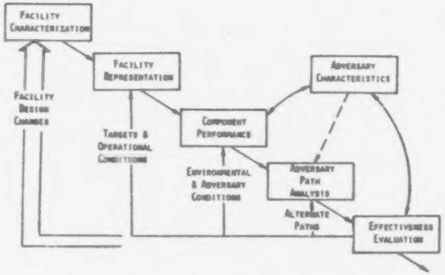
FACILITY CHARACTERIZATION
FACILITY REPRESENTATION
FACILITY DESIGN CHANGES
TARGETS & OPERATIONAL CONDITIONS
COMPONENT PERFORMANCE
ENVIRONMENTAL & ADVERSARY CONDITIONS
ADVERSARY CHARACTERISTICS
ADVERSARY PATH ANALYSIS
ALTERNATE PATHS
EFFECTIVENESS EVALUATION

Figure 1. Physical Protection Evaluation Process

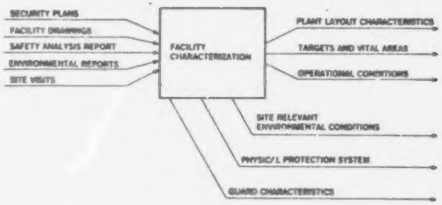
SECURITY PLANS
FACILITY DRAWINGS
SAFETY ANALYSIS REPORT
ENVIRONMENTAL REPORTS
SITE VISITS
FACILITY CHARACTERIZATION
PLANT LAYOUT CHARACTERISTICS
TARGETS AND VITAL AREAS
OPERATIONAL CONDITIONS
SITE RELEVANT ENVIRONMENTAL CONDITIONS
PHYSICAL PROTECTION SYSTEM
GUARD CHARACTERISTICS

Figure 2. Facility Characterization Phase

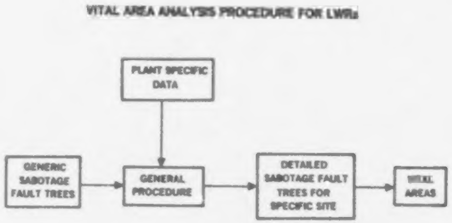
VITAL AREA ANALYSIS PROCEDURE FOR LWRs
PLANT SPECIFIC DATA
GENERIC SABOTAGE FAULT TREES
GENERAL PROCEDURE
DETAILED SABOTAGE FAULT TREES FOR SPECIFIC SITE
VITAL AREAS

Figure 3. Vital Area Analysis Procedure for LWRs

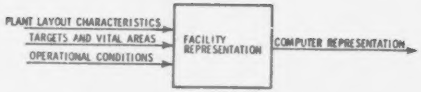
PLANT LAYOUT CHARACTERISTICS
TARGETS AND VITAL AREAS
OPERATIONAL CONDITIONS
FACILITY REPRESENTATION
COMPUTER REPRESENTATION

Figure 4. Facility Representation Phase

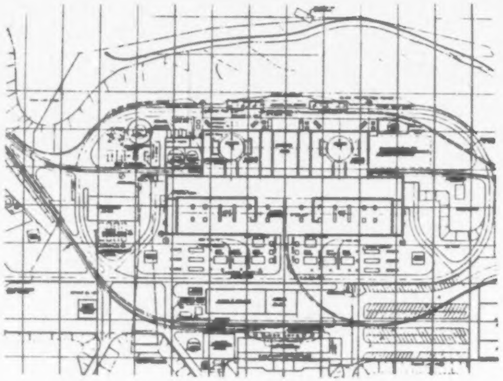

Figure 5. Facility Blueprint - Level 1

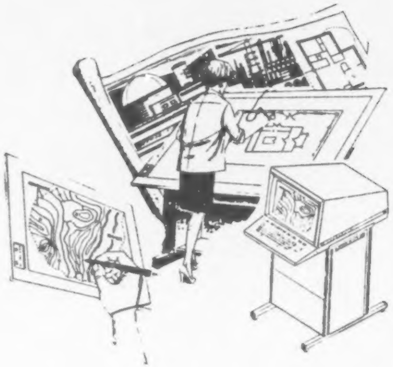

Figure 6. Plant Layout Digitization

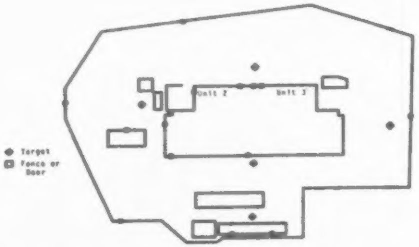
Target
Fence or Door
Unit 2
Unit 1

Figure 7. Plant Layout - Level 1

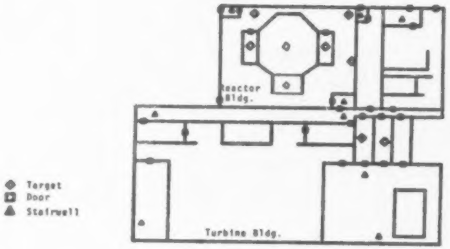
Target
Door
Stairwell
Reactor Bldg.
Turbine Bldg.

Figure 8. Plant Layout - Level 2

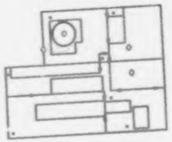

Figure 9. Plant Layout - Level 3

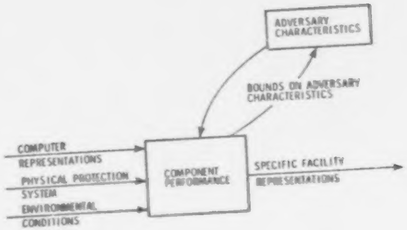
ADVERSARY CHARACTERISTICS
BOUNDS ON ADVERSARY CHARACTERISTICS
COMPUTER REPRESENTATIONS
PHYSICAL PROTECTION SYSTEM
ENVIRONMENTAL CONDITIONS
COMPONENT PERFORMANCE
SPECIFIC FACILITY REPRESENTATIONS

Figure 10. Component Performance

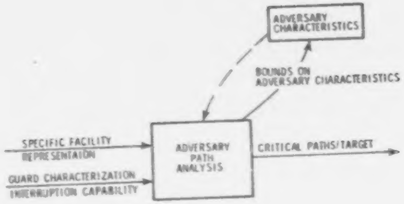
ADVERSARY CHARACTERISTICS
BOUNDS ON ADVERSARY CHARACTERISTICS
SPECIFIC FACILITY REPRESENTAION
GUARD CHARACTERIZATION INTERRUPTION CAPABILITY
ADVERSARY PATH ANALYSIS
CRITICAL PATHS/TARGET

Figure 11. Adversary Path Analysis

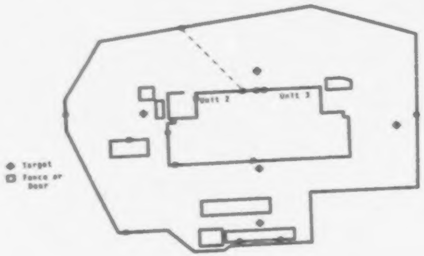
Target
Fence or Door
Unit 2
Unit 3

Figure 12. Adversary Path - Level 1

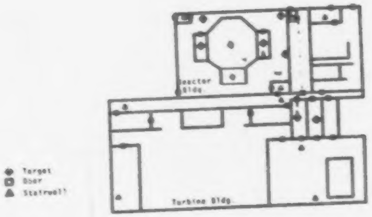
Target
Door
Stairwell
Reactor Bldg.
Turbine Bldg.

Figure 13. Adversary Path - Level 2

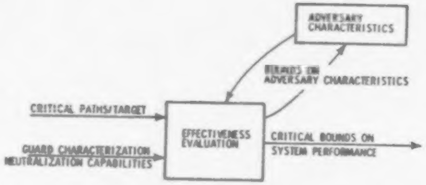
ADVERSARY CHARACTERISTICS
BOUNDS ON ADVERSARY CHARACTERISTICS
CRITICAL PATHS/TARGET
EFFECTIVENESS EVALUATION
GUARD CHARACTERIZATION
NEUTRALIZATION CAPABILITIES
CRITICAL BOUNDS ON SYSTEM PERFORMANCE

Figure 14. Effectiveness Evaluation

ALL TYPE I TARGETS
(7 Minute Response)

TARGETS	VULNERABILITY INDEX	INTERRUPTION LOWER BOUND	NEUTRALIZATION	SYSTEM EFF
221	.68	.87	.92	.80
440	.32	.95	.92	.87
438	.08	.97	.92	.89
224	.07	.97	.92	.89
439	.03	.98	.92	.90
703	.02	.98	.92	.90
523	0.00	.99	.92	.91
441	0.00	1.00	.92	.92

Figure 15. Global Results from SAFE

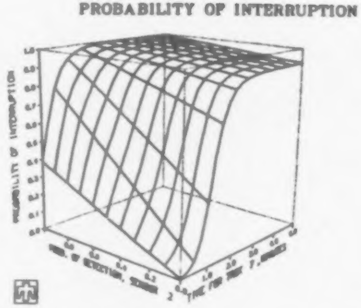

Figure 16. SAFE Sensitivities

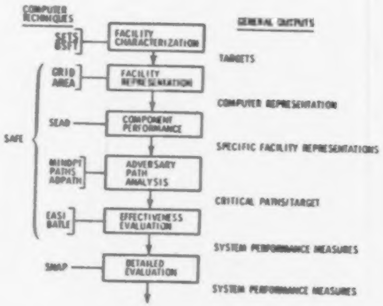
COMPUTER TECHNIQUES
GENERAL OUTPUTS
SETS
FACILITY CHARACTERIZATION
TARGETS
GRID
AREA
FACILITY REPRESENTATION
COMPUTER REPRESENTATION
SAFE
SEAD
COMPONENT PERFORMANCE
SPECIFIC FACILITY REPRESENTATIONS
MINDPT
PATHS
ADPATH
ADVERSARY PATH ANALYSIS
CRITICAL PATHS/TARGET
EASI
BATLE
EFFECTIVENESS EVALUATION
SYSTEM PERFORMANCE MEASURES
SNAP
DETAILED EVALUATION
SYSTEM PERFORMANCE MEASURES

Figure 17. Physical Protection Evaluation Procedure

References

1. Bennett, H. A., "User's Guide for Evaluating Physical Security Capabilities of Nuclear Facilities by the EASI Method," SAND77-0082, Sandia Laboratories, Albuquerque, NM, June 1977.

2. Engi, D., Shanken, J. S. "PATHfinding Simulation (PATHS) User's Guide," SAND78-2177, Sandia Laboratories, Albuquerque, NM, to be published.

3. Worrell, R. B., "Set Equation Transformation System (SETS)." SLA-73-0028A, Sandia Laboratories, Albuquerque, NM, reprinted November 1976.

4. Hall, R. C., Jones, R. D., "A Scientific Data Base for Safeguards Components," SAND78-1766, Sandia Laboratories, Albuquerque, NM, December 1978.

5. Hulme, B. L., "MINDPT: A Code for Minimizing Detection Probability Up to a Given Time Away From a Sabotage Target," SAND77-2039, Sandia Laboratories, Albuquerque, NM, December 1977.

6. Hulme, B. L., Morgan, C. A., "ADPATH: Adversary PATH Subroutine," SAND79-1205, NUREG/CR-0869, Sandia Laboratories, Albuquerque, NM, to be published.

7. Engi, D., Shanken, J. S., "Brief Adversary-Threat Loss-Estimator (BATLE) User's Guide," SAND78-1136, Sandia Laboratories, Albuquerque, NM, to be published.

8. Grant, F. H., Miner, R. J., Engi, D., "A Network Modeling and Analysis Technique for the Evaluation of Nuclear Safeguards Effectiveness," NUREG/CR-0616, Sandia Laboratories, NM, December 1978.

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ASSESSMENT OF METHODS FOR EVALUATING ADEQUACY OF PHYSICAL PROTECTION SYSTEMS*

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November 1980

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Albuquerque, New Mexico 87185
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ABSTRACT

Generally, the scope of a safeguards evaluation model can efficiently address one of two issues: (1) global safeguards effectiveness or (2) vulnerability analysis for individual scenarios. A brief description of the variety of models developed in these areas will be discussed. Current generation models will be described along with an assessment of their utility and a brief look at future techniques for evaluation ill be noted.

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EXECUTIVE SUMMARY

A brief description of several physical protection modeling techniques is described in this paper. In general, the models are categorized according to scenario based or global effectiveness methods. The rational for development of these models is also presented. Within the paper, descriptions of the early scenario models, the improved scenario models, and current generation models are given. Current generation models such as the Safeguards Automated Facility Evaluation (SAFE) technique and the Safeguards Network Analysis Procedure (SNAP) and a combined global/scenario based modeling approach is presented.

A summary of the current status and an assessment of these models is noted along with a forecast of future techniques for the evaluation of physical protection systems. A number of references is provided to permit the interested reader to obtain more detailed information on these modeling techniques.

9,10

EARLY SCENARIO BASED MODELS

Two of the first safeguards evaluation models which were developed were the Forcible Entry Safeguards Effectiveness Model (FESEM)[1] and the Insider Safeguards Effectiveness Model (ISEM)[2]. FESEM and ISEM employ Monte-Carlo techniques to simulate a group of adversaries attacking a nuclear facility. The principle difference between these two models lies in the hypothesized threat that they are structured to address. FESEM was structured to consider primarily adversaries who do not have authorized access to the facility (outsiders) while ISEM focuses on adversaries who do have authorized access (insiders).

The focus of each of the models is defined in terms of the hypothesized threat (outsiders vs. insiders), and their internal structures reflect that difference in emphasis. For example, the neutralization (battle) submodel within FESEM can accommodate any number of adversaries. In contrast, although ISEM can consider any number of adversaries who might covertly tamper with the detection system, its neutralization submodel can accommodate only one adversary who can become engaged in combat with the security force. These Monte-Carlo simulation programs consider a single target and a single adversary path and include simple engagement models. These models also required the use of large computers.

Experience gained through the application of FESEM and ISEM provided the impetus for further safeguards methodology development. There were essentially two schools of thought regarding the most fruitful direction for further developmental work. On the one hand it was clear that the single scenario orientation of FESEM and ISEM was not amenable to an evaluation of safeguards systems considered in their entirety. That is, an evaluation of the effectiveness of a safeguards system deal with those scenarios - it is likely to imply little of the safeguards system as a whold. Consequently, a need for a global approach to the problem of evaluating safeguards system effectiveness was identified. At the other extreme, both FESEM and ISEM were criticized for not including a sufficient amount of detail in individual scenarios. This criticism was directed primarily at their inability to represent complex tactics that might be used by the adversaries as well as the security force.

To satisfy both of these concerns, developmental activities proceeded along two lines. ONe area of work centered on the development of detailed scenario models. This work resulted in a second generation of scenario models that can explicitly represent quite complex tactics. The other area of work focused on developing a global approach to safeguards effectiveness evaluation. The result of the global effort is an interlinked collection of analytical techniques which can be used to evaluate the effectiveness of the entire safeguards system. These analytical techniques allow for a significant simplification and facilitate a global treatment of the problem. The next sections describe in more detail the products of these two developmental activities.

IMPROVED SCENARIO MODELS

The primary thrust in the development of the second generation scenario models was in the direction of enhancing the capability to represent complex tactics. This enhanced capability was pursued through the development of two separate scenario models. One of these models, the Fixed-Site Neutralization Model (FSNM)[3], was developed with the intent of representing tactics internally in the model's logic with a minimal amount of user input of a tactical nature. The other scenario based model, the Safeguards Network Analysis Procedure (SNAP)[4], is the antithesis of FSNM with respect to the representation of tactics. SNAP requires explicit user input to represent the tactical process. Both models employ Monte-Carlo techniques to simulate randomness in the scenario. Outputs from the models include estimates for a variety of system performance measures.

Fixed-Site Neutralization Model (FSNM)

FSNM consists of a representation of the facility and personnel along with their activities and decision processes. The facility is represented in the model as a rectangular area which may, and probably should, extend beyond the boundaries of the actual facility. Architectural features of the facility, such as buildings, fences, walls, and outside areas (yards) are represented, together with interior features such as roofs, floors, stairs, doors, rooms, and walls. Such details as the visibility through a barrier, the difficulty of penetrating the barrier, and whether a door is closed or open, locked or unlocked, are explicitly modeled. The locations of sensors and their types, coverages, and operational states also appear in the facility description. The goals of the adversary are represented by specifying locations in the facility which are required to be occupied by some number of adversaries, possessing certain equipment, for a certain length of time.

Individual persons in the model, called "players", are represented in considerable detail. The representation has three aspects: physical, potential, and psychological. Adjustment of any or all of these aspects permits the simulation of differences between individuals or forces due to training, ability, or equipment. The physical aspect of a player's representation includes his location, posture, weapons and equipment, and physical status. The weapons and equipment a player carries may include pistols, rifles, grenades, light antitank weapons, ladders, keys, and other equipment. The characteristics of each type of weapon, including range, ammunition supply, and effectiveness against various targets, are represented.

Players in the model have three main activities in which they may decide to engage during a simulation time period. These activities are to move, fire, or observe. Other activities may also occur, including surrendering to or capturing an opponent. Every player has an associated collection of perceptions about observable entities (people, vehicles, and sensors) at the facility. These perceptions form, in effect, the "memory" of a player and may change as the result of direct observation by the player or by his reception of information from other players over communication systems.

Safeguards Network Analysis Procedure (SNAP)

SNAP is a simulation language developed specifically for modeling safeguards systems. With the SNAP approach, the analyst constructs a model of the safeguards system by interconnecting a set of SNAP symbols to represent the system elements and their interactions. The resulting SNAP networks are then transferred to a computer compatible form by data cards representing the symbols and their interconnections.

Using the SNAP procedure for safeguards modeling, one combines knowledge of the system, scenarios, modeling objectives, and the SNAP symbology to develop a network model of the system under consideration. This network model is a graphic representation of the nuclear facility, guard operating policies and adversary attack scenario. Typically, the elements of this network model will form a one-to-one correspondence with the components of the actual physical system and scenario being studied. Due to this relationship, a SNAP network provides an excellent communications vehicle. SNAP symbols have been designed to represent the individual elements of a nuclear safeguards system, thus the translation from a system element to the SNAP symbol should be direct.

A SNAP network model is composed of the facility subnetwork, the guard subnetwork, and the adversary subnetwork which interact to produce the overall behavior of the safeguards system. Items which flow through network models are referred to as transactions. The transactions which flow through a SNAP network are guard forces and adversary forces. The force is the most fundamental level of detail in SNAP and represents one or more individuals acting as a single unit.

The facility subnetwork is the most basic of the three networks. It is a static network in the sense that transactions do not flow through it during the simulation. Its purpose is to define the various elements of the facility and their relationships. These elements may include fences, yards, nuclear material, storage vaults, doorways, rooms, sensors, etc. The guard subnetwork defines guard operating policies and includes a representation of the guards' decision logic as well as their physical movement through the facility. Guard forces are the transactions which flow through the guard subnetwork. The adversary subnetwork is treated in a similar manner.

The flexibility afforded by SNAP makes it the preferred approach to modeling scenarios. In effect, all of the modeling capabilities of FESEM and ISEM are included in SNAP. Moreover, if a sufficient amount of detail is incorporated into the facility, adversary, and guard submodels the level of resolution can be equal to that of FSNM. It is worth noting that the inherent flexibility of SNAP is a result of the modeling philosophy used in its development. That is, the SNAP analysis program can be viewed as a simulation "language" specially tailored to model safeguards scenarios.

With the advent of SNAP, the majority of the criticism directed at the limitations pertaining to the representation of detail of the early scenario models (FESEM and ISEM) was answered. SNAP can be used to represent quite complex tactical situations and, as a consequence, lends credibility to the evaluation of individual scenarios. In the context of "vulnerability analyses", SNAP is a valuable tool in that it can provide insights into the strengths (or weaknesses) of the safeguards system in defending against a predefined adversary scenario. However, as previously observed, the analysis of a single scenario is likely to offer little in the way of global insights with respect to the safe guards system. Moreover, even without considering analyst time, a detailed analysis of a sufficient number of scenarios to gain these global insights is unlikely to be computationally tractable. In addition, it is not obvious just what is implied by "a sufficient number of scenarios". To address these inherent limitations which are inexorably linked to any scenario based technique, a global approach to the evaluation of safeguards effectiveness was developed.

Logic Models

During this same period, logic models were developed to support the safeguards efforts. These models were primarily developed around fault tree logic. One model, the Generic Sabotage Fault Tree (GSFT)[5], was designed to identify the sabotage events which, in proper combination, can lead to the release of radioactive material from the nuclear power plant. Through the logic of the fault tree, this determination defines where in the facility a saboteur must go in order to initiate radioactive release. These areas are normally referred to as Type I and Type II vital areas within the facility. A Type I vital area is an area in which the adversary is required to visit one location in order to be successful in accomplishing the sabotage goal. Type II vital areas are those areas in which the adversary is required to visit more than one location in order to accomplish sabotage. This technique is currently being applied to all operating nuclear power plant facilities as part of the Nuclear Regulatory Commissions' safeguards review process.

Another type of fault tree/event tree model called the Adversary Sequence Diagram (ASD)[6] was developed to address generic ways the adversary could accomplish sabotage. This technique decomposed the threat into force, stealth, and deceit and considers the most stressful situation for each component in the safeguards system. The ASD provides a logical approach to identifying vulnerabilities in the safeguards systems.

CURRENT GENERATION MODELS

The principle limitations of the scenario based models with respect to their applicability to a global safeguards effectiveness evaluation were observed to be of a philosophical as well as a technical nature. First, on the technical front, the scenario based models involve relatively complex Monte-Carlo simulation techniques. In addition to the significant amount of computer time necessary to replicate a sufficient number of times to obtain statistical stability, the time required of the safeguards analyst in preparation of the input for a single scenario can be excessive. Perhaps more importantly, the modeling philosophy of the scenario based models does not include the "generation" of adversary scenarios.

The Safeguards Automated Facility Evaluation (SAFE)[7] methodology evolved as a result of efforts to overcome the limitations described above. The technical limitations were addressed by developing a set of analytical techniques which are computer-time efficient and by structuring a highly user-oriented approach that is analyst-time efficient. On the philosophical level, techniques for generating "optimal" adversary scenarios were developed.

SAFE consists of a collection of functional modules for facility representation, component selection, adversary path analysis, and effectiveness evaluation. SAFE combines these modules into a continuous stream of operations. The technique has been implemented on an interactive computer time sharing system and makes use of computer graphics for the processing and presentation of information. Using this technique, a global evaluation of a safeguards system can be provided by systematically varying the parameters that characterize the physical protection components of a facility to reflect the perceived adversary attributes and strategy, environmental conditions, and site operational conditions.

The SAFE procedure requires as input, a blueprint of the facility, showing the facility layout characteristics, the targets, and vital areas. To obtain this input, the analyst must perform a facility characterization activity[6]. Relevant sources of information for this activity include the security plans, facility drawings, safety analysis reports, environmental reports, and site visits. Based upon this information, the analyst must synthesize the necessary facility layout characteristics, targets and vital areas, operational conditions, site-relevant environmental conditions, physical protection system and guard characteristics for which analyses are to be performed.

The first step in the application of SAFE is to construct a computer representation of the facility. This representation provides an explicit record of the analyst's assumptions concerning the facility. For example, the analyst would indicate all principle barriers and obstacles to adversary movement, all points of potential ingress and egress, floor levels and interconnections, and targets and vital areas for specific operational conditions. This information is used to organize and digitize the pertinent facility information into a computer usable form. The final output of the facility representation is a graph in which nodes represent potential access points or targets, and arcs represent possible movement between nodes.

The next phase in the SAFE analysis requires the analyst to set component performance for individual safeguards elements. The specific performance for both hardware and personnel "components" should be based upon relevant sets of environmental and adversary conditions. The analyst uses the component performance to determine weights for all nodes and arcs in terms of detection probabilities and time delays for adversary penetrations. Appropriate selection of these weights provides bounds for a range of adversary attributes. The resultant graph-theoretic representation serves as input to the adversary path analysis module within SAFE.

The generation of adversary scenarios is achieved by selecting optimal paths through the facility for the adversary. Both theft and sabotage path selection were previously accomplished by several alternative techniques[8,9,10,11]. Currently, SAFE uses one of three measures for a versary pathfinding: 1) minimum adversary task time, 2) minimum adversary detection probability, and 3) minimum timely-detection of the adversary. Within SAFE, these measures can be either deterministic[12] or stochastic[13]. In effect, the timely-detection method generates paths which minimize the probability that the security force can confront (or interrupt) the adversary. The output of the adversary path analysis is a collection of ordered sets of node identifiers that represent physical paths in the facility which are the most "critical" in terms of the measure being used. This information is a portion of the input to the effectiveness evaluation module in SAFE.

Effectiveness evaluation can be decomposed into two major parts: interruption and neutralization for a given path. The path is "evaluated" by first determining the probability that the adversary will be interrupted and then determining the probability that the adversary will be neutralized or defeated by the security force. These two probabilities can be multiplied together to yield the total probability that the physical protection system will be successful in defending against the adversary along the path under consideration.

The Estimate of Adversary Sequence Interruption (EASI)[14] model is an analytical technique which is used in the effectiveness evaluation module to compute the probability that the adversary will be interrupted. EASI focuses on the adversary path and requires information related to the probability of detecting the adversary, the time required for determining the proper response, the probability of communication with the security forces, the delay along the adversary path and the response time of the security force. The output of EASI is an estimate of the probability of adversary interruption along the specified path, i.e., the probability that the security force arrives at a point along the adversary's path prior to the time that the adversary passes through that point.

The Brief Adversary Threat Loss Estimator (BATLE)[15] model is an analytical technique that is used to estimate the probability that the adversary is neutralized by the security force. In addition to the distance between combatants, the information required by BATLE is the type of weapons, the recency of training, the amount of cover, and the number and timing of arrivals of reinforcements for the adversary as well as the security officers. The output of BATLE includes the probability that the adversary is neutralized by the security force. This "neutralization probability" is then multiplied by the "interruption probability" to yield the total probability of success of the physical protection system for the path in question.

Capabilities for effectiveness evaluation can be utilized in either a single or multipath mode. During a single path evaluation using EASI, the probability of interruption is calculated and the user may request two- or three-dimensional plots which show the probability of adversary interruption or probability of system win as a function of one or two of the input variables[16]. Based on the probability of interruption, these graphs illustrate sensitivities related to upgrading the facility. The multipath option displays in tabular form the probability of interruption, the traversal time of each path, and the frequency at which nodes appear in the set of critical paths. The multipath evaluation identifies paths that are particularly vulnerable and thus are candidates for study by more elaborate evaluation modules such as the scenario based models previously described.

A Combined SAFE/SNAP Approach

Generally, the scope of a safeguards evaluation model can effectively address one of two issues:

1) global safeguards effectiveness, or
2) vulnerability analysis for individual scenarios

SAFE addresses 1) in that it considers the entire facility; i.e., the composite system of hardware and human components, in one "global" analysis. SNAP addresses 2) by providing a safeguards modeling symbology sufficiently flexible to represent quite complex scenarios from the standpoint of hardware interfaces with other elements of the physical protection system while also accounting for a rich variety of human decision making.

A combined SAFE/SNAP approach to the problem of safeguards evaluation logically proceeds along the following lines:

1) Initially, apply SAFE to identify global safeguards vulnerabilities,
2) Represent these vulnerabilities in scenarios that can be analyzed using SNAP.

Conceivably, insights of a global nature (especially as they relate to guard tactics and deployment strategies) could be gained from the SNAP vulnerability analysis. These insights might be formally "fedback" to SAFE, thus closing the global/scenario evaluation loop.

SURE Methodology

Another model called the Safeguards Upgrade Rule Evaluation (SURE)[17] methodology is based upon probability and utility theory concepts. The SURE method utilizes a hierarchical structure derived from a decomposition of the NRC rules (10 CFR 73.45) for fuel cycle facilities. This functional decomposition continues down to the safeguards component level. At the component level, questionnaires must be answered to assess the effect of various factors on component performances, i.e., operation, maintenance, and environmental effects on hardware and proficiency level and completeness of procedures. Ultimately, this information is aggregated through each level of the structure to arrive at an overall measure of compliance with the regulatory requirements of the NRC rules. This method allows the opinions of experts to form the basis for the input of the model. SURE also provides a very clear traceability of system performance from the component performance level for equipment, personnel and procedures to the requirements of the rule.

CURRENT STATUS OF METHODS

For an outsider adversary with the intent of creating sabotage at a nuclear power plant, methods (SAFE and SNAP) exist to provide the anlayst with sufficient capabilities to address the important safeguards problems. Limitations exist on input data in the detection area and human performance area relative to security officers. The human responses dealing with neutralization will always be an area with insufficient data and an area for which live experiments of battles cannot be conducted to adequately validate neutralization models. Due to the complexity of physical protection problems, information gained by exercising the evaluation models should be utilized in a supplementary way for aiding the safeguards analyst in his decision making process.

For the insider reactor sabotage problem, only limited modeling techniques exist for addressing the acts of sabotage. Methods to address the detection of plant operational states which could lead to radioactive release are yet to be developed. These techniques will be addressed during FY 81 through current NRC research programs. Questions dealing with compartmentalization, access authorization, work rules, and operational impacts are only now being addressed from a research point of view.

FUTURE ASSESSMENT METHODS

The near term methods to be developed for assessment of reactor safeguards systems will encompass the decomposition of the NRC rules to the component level using a highly logical fault tree structure. This method should become available in FY 82. In addition, the Multiple Integrated Laser Engagement System (MILES)[18] will be utilized to test both the training of security officers and the security system at the nuclear power plant.

CONCLUSIONS

There currently exist adequate models for addressing the outsider reactor sabotage problem. This assessment is primarily based upon a comparison of available input data versus the level of modeling detail. Insufficient data will always exist in this area and therefore extensive detail in a given model will be of little utility. The purpose of these models must be kept in mind when one utilizes a safeguards model. If the output of the modeling analysis provides useful information for the safeguards analyst, then the models possess a high degree of utility. On the other hand, methods for addressing the insider reactor problem in a comprehensive sense are currently under development and should become available in the 1981-82 time frame.

REFERENCES

1. L. D. Chapman, et al., Users Guide for Evaluating Alternative Fixed-Site Physical Protection Systems Using "FESEM", SAND77-1367 (Albuquerque: Sandia National Laboratories, November 1977).

2. D. D. Boozer, D. Engi, Insider Safeguards Effectiveness Model (ISEM) Users Guide, SAND77-0043 (Albuquerque: Sandia National Laboratories, November 1977).

3. D. Engi, et al., Fixed-Site Neutralization Model, Volume I, Executive Summary, SAND79-0064 (Albuquerque: Sandia National Laboratories, January 1979).

4. F. H. Grant, et al., A Network Modeling and Analysis Technique for the Evaluation of Nuclear Safeguards Effectiveness, NUREG/CR-0616 (Albuquerque: Sandia National Laboratories, December 1978).

5. G. B. Varnado, Reactor Safeguards System Assessment and Design, Volume I, SAND77-0644 (Albuquerque: Sandia National Laboratories, June 1978).

6. A. E. Winblad, et al., Preliminary Engineered Safeguards System Design for a Mixed-Oxide Fuel Fabrication Facility, Volume III, SAND77-1155 (Albuquerque: Sandia National Laboratories, January 1979).

7. L. D. Chapman, et al., Safeguards Automated Facility Evaluation (SAFE) Methodology, SAND780378 (Albuquerque: Sandia National Laboratories, August 1978).

8. B. L. Hulme, Graph Theoretic Models of Theft Problems. I. The Basic Theft Model, SAND75-0595 (Albuquerque: Sandia National Laboratories, November 1975).

9. B. L. Hulme, Pathfinding in Graph-Theoretic Sabotage Models. I. Simultaneous Attack by Several Teams, SAND76-0314 (Albuquerque: Sandia National Laboratories, July 1976).

10. B. L. Hulme, D. B. Holdridge, SPTH3: A Subroutine for Finding Shortest Sabotage Paths, SAND77-1060 (Albuquerque: Sandia National Laboratories, July 1976).

11. B. L. Hulme, D. B. Holdridge, KSPTH: A Subroutine for the K Shortest Paths in a Sabotage Graph, SAND77-1165 (Albuquerque: Sandia National Laboratories, August 1977).

12. B. L. Hulme, MINDPT: A Code for Minimizing Detection Probability Up To a Given Time Away From a Sabotage Target, SAND77-2039 (Albuquerque: Sandia National Laboratories, December 1977.

13. D. Engi, J. S. Shanken, PATHfinding Simulation (PATHS) User's Guide, SAND78-2177 (Albuquerque: Sandia National Laboratories, to be published).

14. H. A. Bennett, User's Guide for Evaluating Physical Security Capabilities of Nuclear Facilities by the EASI Method, SAND77-0082 (Albuquerque: Sandia National Laboratories, June 1977).

15. D. Engi, C. P. Harlan, Brief Adversary Threat Loss Estimator BATLE) User's Guide, SAND80-0952 (Albuquerque: Sandia National Laboratories, October 1980).

16. D. W. Sasser, User's Guide for EASI Graphics, SAND78-0112 (Albuquerque: Sandia National Laboratories, March 1978).

17. H. A. Bennett, M. T. Olascoaga, Design Guidance and Evaluation Methodology for Fixed-Site Physical Protection Systems, Volume I and II, SAND79-2378 (Albuquerque: Sandia National Laboratories, March 1980).

18. R. L. Wilde, Small Force Engagement Experiment (SFEE), SAND79-2473 (Albuquerque: Sandia National Laboratories, February 1979).

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August 16, 1982

Dr. James P. Shipley
Assistant Division Leader/Program
Manager Safeguards and Security
Los Alamos National Laboratory
Los Alamos, NM 87545

Dear Dr. Shipley:

We appreciated having you testify on the Los Alamos National Laboratory's safeguards research and development programs at the Subcommittee's hearing on August 4, 1982. Chairman Bouquard would like to supplement the record of the hearing with some additional questions regarding the programs. We appreciate your cooperation on this matter and we hope that this information can be provided by September 7, 1982.

If you have any general questions regarding these requests, please contact me at 202/225-8056. If you have any questions regarding the specifics, please contact Dr. Harlan Watson of the Subcommittee staff at 202/225-3472.

Sincerely,

John V Dugan Jr/jms
JOHN V. DUGAN, Staff Director
Subcommittee on Energy Research
and Production

JVD:Wjs
Enclosures

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
CHAIRMAN BOUQUARD'S QUESTIONS ON
TECHNICAL ASPECTS OF NUCLEAR NONPROLIFERATION: SAFEGUARDS
Hearing held August 4, 1982

1. It is stated that typically, portable, easy-to-operate equipment has been supplied to the IAEA for field inspections, whereas larger, more sophisticated inplant equipment has been supplied for domestic uses. How would you compare the performances of the portable equipment versus the in-plant equipment? Will portable equipment be able to do the whole job?

2. The need for closer interaction between safeguards R&D and operations personnel is noted in the testimony. Is this happening at all today? What suggestions do you have to improve the situation?

3. FY 1982 budget figures are provided for safeguards R&D activities at Los Alamos. What were the corresponding figures for FY 1981 and what are the expected figures for FY 1983?

4. It is indicated that Los Alamos interacts with foreign countries in safeguards. Does Los Alamos deal directly with safeguards scientists and engineers of other nations, or is this interaction filtered through Washington?

5. What is the nature of LANL's participation in the International Working Group on Reprocessing Plant Safeguards? Do LANL personnel participate directly as U.S. representatives, or as advisors to U.S. officials? Can they speak their mind, or must they hold to a Washington position?

6. LANL is clearly a U.S. and a world center for important kinds of safeguards work, and that importance inescapably brings influence. What guidelines does LANL have for use of that influence? Does LANL attempt to use it consciously, or let it work indirectly through the collective views and attitudes of its staff?

7. Measurements of sensitive nuclear materials surely date back 40 years or more to the Manhattan Project. Why, after all this time, are we deficient in detailed assay procedures? Is this the result of lack of inattention of Federal R&D programs or because of fundamental laws of nature?

8. Lack of proper physical standards for calibration of equipment is noted as a technical deficiency of current safeguards. Hasn't the National Bureau of Standards provided some physical standards? What is NBS's role in this area? Should it be expanded, or does one of the DOE laboratories have the lead responsibility for developing and providing proper physical standards?

9. Lack of commercial supply and maintenance services are noted. Is this a situation where an ideological predisposition to commercial sources is keeping necessary equipment away from the IAEA? Couldn't an IAEA laboratory, a DOE laboratory, or some international laboratory provide equipment and maintenance services?

10. What is the reason for the lack of integration of various safeguards subsystems? Is this the result of a situation where different organizations each have different responsibilities and are unwilling to surrender their individual authorities?

11. It is noted that an effective safeguards program necessarily incorporates a strong educational activity. Who should be responsible for this? Should it be the DOE, the NRC, or some other organization?

12. IAEA's safeguards responsibilities for large, bulk-handling facilities will increase, and it is suggested that adequately and economically safeguarding these faciliites will "necessitate significant changes in the way international safeguards are done and in the programs that support them."

    a. What changes are needed?

    b. Will present safeguards R&D produce needed improvements, and if not, what additional R&D or changes in present R&D are indicated?

13. If you had it within your power and authority to devise a different scheme or organizational format for conducting international and domestic safeguards research and development, how would you change the current set-up?

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

DATE: 26 August 1982
IN REPLY REFER TO: Q-DO/SG-82-299
MAIL STOP: E550
TELEPHONE: 667-6394

Dr. John V. Dugan
Staff Director
Subcommittee on Energy Research
and Production
House Committee on Science and Technology
Room B374 Rayburn House Office Building
Washington, DC 20515

Dear Dr. Dugan:

I am supplying the following material in response to your request of August 16, 1982 for supplementary information on the Safeguards Research and Development Program at the Los Alamos National Laboratory. I appreciate the opportunity to provide additional information on these questions.

- Performance Comparison of Portable Equipment Versus Inplant Equipment.

  In general, portability of a measurement device has a small effect on its measurement performance. That is, two measurement devices, each based on the same fundamental physical principles and measuring the same type and form of nuclear material, but one being portable and the other being an in-plant device, will exhibit only minor differences between their measurement errors. The advantage of in-plant equipment comes about because there is a wider range of such devices available that may be better suited to particular measurement situations. It is usually easier to tailor an in-plant measurement device to a specific application because it is most often dedicated to one or at most a few measurement situations, which means that measurement errors can usually be made somewhat smaller than for a comparable portable device. However, that difference is not likely to be large. The other advantage enjoyed by in-plant equipment concerns the relative ease of systematic data acquisition, analysis, and display.

Portable equipment, given a sufficient amount of it, and a sufficient number of inspectors to transport and use it, can certainly do a large part of the international safeguards job. However, for future large bulk-handling facilities that will likely accommodate continuous inspector presence, the need for equipment to be portable is less clear. It may be possible for the inspector to rely more heavily on in-plant equipment, with its associated advantages, and much less on having to bring along portable equipment each time a facility visit is made. In that case the in-plant equipment developed for domestic uses would provide a significant technological springboard for international safeguards.

- Interactions between Safeguards R&D and Operations Personnel.

In terms of domestic safeguards, these interactions have been of increasing intensity for some time. They must continue to be nurtured by both sides to assure adequate consideration for the sensitivities and constraints on all concerned.

At the IAEA, interactions between the Divisions of Operations and the Division of Development have been less extensive than might be desired, but I believe this situation, too, is improving. For example, Los Alamos now has an individual (Dr. G. Robert Keepin) serving as a special assistant to Hans Gruemm, the Deputy Director General for Safeguards of the IAEA, whose function is to promote the transfer of technology from the development stage to the operational stage. In addition, Los Alamos trains most of the new IAEA inspectors in the use of NDA equipment. I think this educational activity is part of the key. The other part is making sure that the safeguards R&D personnel are aware of the problems of operations personnel. This can be done by inserting R&D personnel into the operations environment. Los Alamos does this by sending several of its staff to work in the Divisions of Operations as IAEA-paid employees every year.

- Los Alamos Safeguards R&D Budget Figures for FY 1981 and 1983.

In FY 1981 DOE/OSS support at Los Alamos was approximately 8.2 million dollars, and the POTAS- and NRC-sponsored activities were approximately the same as in FY 1982, that is, 0.8 million dollars and 0.5 million dollars respectively. The expected figures for FY 1983 are precisely the same as those for FY 1982, i.e., constant funding, which means a reduced level of effort.

- Los Alamos Interactions with Safeguards Scientists and Engineers of Other Nations.

On technical matters, Los Alamos deals directly with the US and international safeguards communities. DOE/OSS, State Department, and ACDA are kept informed of these interactions as a matter of course. These agencies have promoted free technical exchanges with a notable lack of attempted filtration, constraint, or proscription.

- Los Alamos Participation in the International Working Group on Reprocessing Plant Safeguards.

  Los Alamos personnel have generally functioned as technical representatives and as technical advisors to US officials participating in these meetings, and on occasion as the US representative. In all cases we have been free to speak our minds on technical issues.

- How Does Los Alamos National Laboratory Use Its Influence In Safeguards.

  The influence that Los Alamos has in the field of safeguards stems from its technical capability. Consequently, its influence can only be directed at the technical bases of the issues at hand. The Laboratory has had a long tradition and a strong belief in the professional excellence of its staff and has never hesitated to make that collective expertise available. Within this framework, there are no externally imposed guidelines.

- Deficiencies in Detailed Assay Procedures.

  Such deficiencies as exist stem from two causes: 1) the continually increasing number of types and forms of nuclear materials that occur as a natural consequence of the spread of nuclear power, and 2) the desire for increasingly accurate and precise measurements as we try to improve our stewardship over these nuclear materials, which necessitates the development of new assay techniques, greater exploitation of existing technology, and tailoring for the international safeguards community. Thus, the deficiencies are not caused either by fundamental laws of nature or by lack of attention of the Federal R&D programs, but rather by the natural time delay between the emergence of materials to be measured and the development of sufficiently good measurement techniques.

- Physical Standards for Equipment Calibration.

  The National Bureau of Standards has certainly made significant contributions, mainly in the area of providing primary physical standards and some secondary standards materials. However, the real need is for working standards that would be available on a daily basis and are closely matched to the highly specific requirements of each facility and its associated measurement techniques. The number of working standards required for each facility is potentially in the hundreds. Such working standards can only be obtained by close interaction with operating facilities. There is, in fact, a significant standards development activity of this nature for which the New Brunswick Laboratory has lead responsibility in domestic safeguards. Los Alamos contributes heavily to that program. The standards program for international safeguards is less well developed and still emerging. Currently, various international organizations are engaged in discussions on the specific needs for standards.

- Lack of Commercial Supply and Maintenance Services.

  Any predisposition to commercial sources is not an ideological one but one arising from the cost and resource availability associated with alternative sources. It is possible that an IAEA laboratory or some international laboratory could provide the necessary equipment and maintenance services if sufficient money, and time to gear up, were available. It is likely that such a function would lie outside the mandate of the DOE laboratories.

- The Lack of Integration of Various Safeguards Subsystems.

  Institutional prerogative has played some small role in inhibiting integration in the past, but it is now a secondary factor. I believe that currently there are two major causes. First, the relative capabilities of the various safeguards subsystems are not sufficiently well known and demonstrated in specific facilities to allow agreement on the proper mix of subsystems. This is an area that requires further experience and development. Second, methods for doing the integration of such complex subsystems are not yet well defined. Again, such methods are currently under development. It should be noted that differences in facilities cause each integration to be unique in detail; as a result, integration is not a turnkey effort.

- Responsibility for Safeguards Educational Activities.

  Education in safeguards must be carried out by a combination of safeguards R&D and operations personnel as the people most capable of seeing both safeguards problems and solutions in sufficient detail to provide the required educational level to the safeguards community. I believe this activity is properly the responsibility of DOE/OSS. Los Alamos, in material control and accounting, and Sandia in physical protection, in conjunction with other national laboratories and agencies, are currently performing this role as part of its program for DOE/OSS.

- a. Changes in International Safeguards and Their Supporting Programs.

  In terms of changes in IAEA safeguards, the Agency must aim toward continuous inspector presence for bulk-handling facilities and for improved inspection capability. In my view, this means relieving inspectors of those duties that can be done far better by a machine (e.g., auditing the materials accounting records or making long sequences of repetitive measurements), giving them sufficient time and freedom to perform those subjective activities that cannot be done by machine (e.g., observing the current emotional climate in a facility), and augmenting these capabilities with the sophisticated technology of in-plant measurement devices that do not require a highly trained technician to use, are reliable, and can be secured from tampering by a potential divertor.

The support programs must facilitate these objectives, which in my opinion will require more attention to the entire inspection regime as opposed to concentration on various relatively small aspects of it, as has been the case in the past. To get to the point where such an approach is acceptable, the technology will have to be demonstrated to work to the satisfaction of the international community. Of course, this must be an evolving process concurrently with the development of the technology.

b. Changes in safeguards R&D.

The current domestic R&D program will substantially benefit international safeguards. I believe a large part of the problem will be transferring that technology in such a manner that it will be used. Of the remaining R&D changes that are needed, the major one is the development of a more systematic procedure for designing safeguards systems that are demonstrably effective to a quantifiable extent.

- New Scheme for Conducting Safeguards R&D.

Currently the domestic R&D program is functioning rather well. I still see the need for closer interaction between safeguards practitioners and facility operators, but that is changing for the better all the time. The international safeguards side can benefit from better management at the IAEA in terms of fewer institutional barriers among the various organizations that must assist one another to be maximally effective. With respect to the US program supporting the IAEA, I believe that its effectiveness would be enhanced by concentration of resources on a relatively small number of problems that are likely to be of lasting importance to the Agency and its members. It is my opinion that in the past we have tended to take on lots of little projects that are responsive to immediate IAEA concerns but that too often have had minimal long-term benefit. This approach was perhaps necessary initially to become familiar with the field, but I think the time has come for a more systematic viewpoint and an attempt to influence the IAEA more actively on the course the US support program should take.

I hope this material is responsive to your needs. I would be pleased to provide additional information as required.

Sincerely,

Jim

J. P. Shipley
Safeguards and Security

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cy:
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August 16, 1982

Dr. James A. Buckham, President
Allied General Nuclear Services
P. O. Box 837
Barnwell, SC 29812

Dear Dr. Buckham:

We appreciated having you and Mr. Bambas testify on the Barnwell Nuclear Fuel Plant's safeguards research and development programs at the Subcommittee's hearing on August 4, 1982. Chairman Bouquard would like to supplement the record of the hearing with some additional questions regarding the programs. We appreciate your cooperation on this matter and we hope that this information can be provided by September 7, 1982.

If you have any general questions regarding these requests, please contact me at 202/225-8056. If you have any questions regarding the specifics, please contact Dr. Harlan Watson of the Subcommittee staff at 202/225-3472.

Sincerely,

John V. Dugan Jr/jms

JOHN V. DUGAN, JR., Staff Director
Subcommittee on Energy Research
and Production

JVD:Wjs
Enclosures

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
CHAIRMAN BOUQUARD'S QUESTIONS ON
TECHNICAL ASPECTS OF NUCLEAR NONPROLIFERATION: SAFEGUARDS
Hearing held August 4, 1982

1. There have been many criticisms of the Barnwell Nuclear Fuel Plant (BNFP) and claims that Barnwell could not be maintained if put into operation. Would you please respond to these comments? What was the BNFP designed to do, and can it meet the performance standards?

2. Please comment on the economics of reprocessing. What are the current estimates of the cost of heat energy in $/million BTU from nuclear fuel using LEU and estimates using the reusable fissile material recovered by the BNFP? Please include fuel fabrication costs.

3. The testimony says that high-level waste, in chemically stable solid form, would occupy only one-tenth of the volume of the fuel assemblies from which it came. What about the total waste volume? How does the waste volume of all forms of waste from reprocessed fuel compare to the volume from unreprocessed fuel?

4. Is any of the Barnwell safeguards system information considered as sensitive nuclear technology under the Nuclear Non-Proliferation Act of 1978?

5. If you had it within your power and authority to devise a different scheme or organizational format for conducting international and technical safeguards research and development, how would you change the current set-up?

Allied-General Nuclear Services
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J. A. Buckham
President

(803) 259-1711

September 2, 1982

Mr. John V. Dugan, Jr.
Staff Director
Subcommittee on Energy
Research & Production
U.S. House of Representatives
Suite 2321 Rayburn House
Office Building
Washington, D.C. 20515

Dear Mr. Dugan:

Thank you for your letter dated August 16, 1982. This enclosed questions which Chairman Bouquard had raised to supplement the record of our testimony on the Barnwell Nuclear Fuel Plant's safeguards research and development programs. Our response to these questions is attached. If you feel that any additional information would be helpful we would be pleased to hear from you further.

Sincerely,

J A Buckham

J. A. Buckham

JAB/gmb

Enclosure:

9/1/82

ALLIED-GENERAL NUCLEAR SERVICES
RESPONSE TO
SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
CHAIRMAN BOUQUARD'S QUESTIONS ON
TECHNICAL ASPECTS OF NUCLEAR NONPROLIFERATION: SAFEGUARDS
Hearing held August 4, 1982

1. There have been many criticisms of the Barnwell Nuclear Fuel Plant (BNFP) and claims that Barnwell could not be maintained if put into operation. Would you please respond to these comments? What was the BNFP designed to do, and can it meet the performance standards?

The BNFP was designed to reprocess spent fuel from commercial power (LWR) reactors. The basic chemistry of the Purex process used in the BNFP design had been well established and proven through more than 380 plant-years of world operation. Recent criticism that the chemistry of reprocessing is "ill understood" and that problems in "process chemistry" have led to "breakdowns" is simply not true.

The Barnwell "minimum maintenance" design drew heavily on this extensive operating experience in the numerous Purex-type reprocessing plants -- both domestic and foreign -- which preceded it. Proven features of these plants were adopted in the Barnwell design. Conversely, features which had contributed to operating problems in earlier plants were eliminated or corrected. Those equipment items which history had shown to require maintenance or replacement, were designed for remote maintenance. Equipment which experience showed could be relied upon for life-of-the-plant maintenance-free operation was configured for direct or "contact" maintenance. In this contact-maintenance portion of the plant, pumps and other equipment with moving parts have been eliminated; all piping connections have been welded; and, all welds have been radiographed. A similar optimized mix of remote- and contact- maintenance has been adopted in all reprocessing plants recently built or under construction throughout the world.

Criticism of this minimum-maintenance design has not been based on its safety or its ability to comply with all applicable health and environmental standards. Indeed, the plant is designed to meet, and will easily meet, all criteria for protection of the environment and the health and safety of employees and the public. Rather, such criticism has questioned plant maintainability under this mixed maintenance design. This criticism, by those who had neither visited nor had any direct experience with the BNFP, is wholly unfounded.

In contrast, the panels of knowledgeable, experienced, independent experts who have visited the Plant and meticulously reviewed its design and construction have all agreed that the BNFP is fully operable and maintainable. The most recent study was performed in late 1981 under the joint sponsorship of the Electric Power Research Institute and Bechtel National, Inc.

As reported in Nuclear Engineering International, August 1982*, all members of the team had extensive hands-on experience in the operation and maintenance of reprocessing plants. The assessment included a two-week physical inspection of the BNFP, and a review of all pre-operational test data.

The team concurred with the desired modifications identified by BNFP personnel during preoperational tests and concluded, subject to these modifications being made, that the BNFP can operate on a sustained basis at a capacity of about 1200 MTU per year. In arriving at this 1200-MTU rate, the EPRI-Bechtel team acknowledged the BNFP's capability to achieve its rated 5-MTU-per-day capacity, but chose to use 240 operating days per year.

BNFP technical and operating personnel believe that the 240 days per year operating figure is conservative. Moreover, during integrated cold runs using natural uranium as a stand-in material, the BNFP has operated for periods of several hours at rates up to 6.9 MTU per day. Additionally, adoption of the BNFP-developed safeguarding system could eliminate up to 30 days per year now included, for inventory purposes, in plant downtime. However, in order to be conservative, the 1200-MTU-per-year rate is used in economic analyses.

2. Please comment on the economics of reprocessing. What are the current estimates of the cost of heat energy in $/million BTU from nuclear fuel using LEU and estimates using the reusable fissile material recovered by the BNFP? Please include fuel fabrication costs.

In the context of direct impact on an individual's monthly electric bill, recycling recovered fissile material versus the LEU ("once-through" or "throw-away") fuel cycle provides only small direct economic benefits. In fact, the total impact of either alternative amounts to only about one percent of total electric energy costs. Spent fuel in a reactor basin has a negative value in either case. However, credits for the recovered fissile material (including allowance for additional fuel fabrication costs) make recycle less costly than throw-away.

The specific economic benefit of recycle is directly influenced by the price of uranium. Our estimate of the "break-even" price, at which the benefit of recycle versus throw away would be zero, is $11 per lb of U_3O_8. Thus, at any price above $11/lb U_3O_8, recycle is less costly than the alternative of fuel disposal. (As published in a February 1981 Report**, other studies indicate that recycle is less costly even at a zero value for U_3O_8).

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*Restoring Commercial Reprocessing in the United States, A. J. O'Donnell, R. O. Sandberg, and R. E. Brooksbank, Sr.

**Light-Water Reactor Fuel Cycles - An Economic Comparison of the Recycle Throwaway Alternatives, Atomic Industrial Forum, February 1981.

We estimate that the cost of heat energy achieved by reprocessing and recycle is 25 mills/million BTU less than the cost of heat energy from the throw-away alternative. This estimate includes the conservative assumption of 1200 MTU/year throughput at the BNFP discussed in relation to Question 1. At 1500 MTU/year, the cost of heat energy from recycle would be 56 mills/million BTU less than from the throw-away alternative. On the basis of reactors served, reprocessing/recycle benefits, versus throw-away, would range from $1.4 to $4.8 million per reactor per year depending upon assumptions as to U_3O_8 prices, BNFP startup date and capacity.

This modest economic benefit is far overshadowed by the importance of reprocessing to energy resource conservation and improved waste management and disposal. In operation, the BNFP could recover reusable fissionable material which could produce electric energy equivalent to that from burning one million barrels of oil per day. The BNFP is thus important to national energy conservation. Additionally, operation of the BNFP would greatly reduce the volume, the level of hazard, and the period during which waste material could be potentially hazardous. The BNFP, thus, has the capability to make a major contribution to the national nuclear waste management program.

3. The testimony says that high-level waste, in chemically stable solid form, would occupy only one-tenth of the volume of the fuel assemblies from which it came. What about the total waste volume? How does the waste volume of all forms of waste from reprocessed fuel compare to the volume from unreprocessed fuel?

The testimony related to high-level waste (HLW) because it is in this area that the BNFP has the capability to make its most important contribution to the national nuclear waste management program. In addition to volume reduction and conversion to chemically stable form, removal of plutonium reduces the potential hazard of HLW. Moreover, the testimony implicitly recognized that HLW is far more costly to package, transport, and dispose of than other waste categories.

The following table compares the estimated volumes of all forms of containerized waste resulting from reprocessed fuel as compared to the volumes from unreprocessed fuel. Reprocessing wastes are shown in three categories: 1) HLW, 2) Transuranic (TRU) waste which requires disposal at a Federal Repository, and 3) Non-TRU waste which can be disposed of at a commercial shallow-land burial facility.

Fuel Treatment	Waste Category	Unit Waste Volume ft^3/MTU
Unreprocessed Spent Fuel	HLW	40-45
	Other	Undefined*
Reprocessed Spent Fuel	HLW	4
	TRU: Fuel cladding hulls	7
	General process trash	20
	Non-TRU	37

*Non-TRU, and possibly TRU, wastes generated during preparation of fuel for disposal. Quantities have not been estimated.

While there is an increase in overall volume, this is entirely in TRU and non-TRU categories which can be disposed of far more easily and cheaply than HLW. The costs of handling, transporting, and storage of HLW vastly exceed that for other waste categories. Because these costs are primarily proportional to volume, the ten-to-one volume reduction for HLW from reprocessing spent fuel offers appreciable economic advantage.

Moreover, current concepts of disposal for other than HLW categories show promise of further cost reduction. For example, it should be possible to dispose of TRU wastes as backfill at HLW repositories taking advantage of existing tunnels at those sites.

4. Is any of the Barnwell safeguards system information considered as sensitive nuclear technology under the Nuclear Non-Proliferation Act of 1978?

Sensitive Nuclear Technology is defined in the Nuclear Non-Proliferation Act of 1978 ("Act") as "any information...which is not available to the public which is important to the design, construction, fabrication, operation or maintenance of a...nuclear fuel reprocessing facility...". As stated in our testimony, safeguards systems are comprised of two separate but integrated components: physical protection and material accountancy. The Department of Energy has advised that the physical protection component of the Barnwell safeguards system does not constitute "sensitive nuclear technology." The Department has under consideration the question of whether the material accountancy component can be demonstrated without any compromise of such technology.

Reprocessing facilities are being designed and built throughout the world without benefit of information from the Barnwell safeguards system. Dissemination or suppression of Barnwell safeguards system information would neither speed nor impede the design or construction of a reprocessing facility.

Conversely, adoption of such information would have a positive and beneficial effect on the capability, at a reprocessing plant, to protect and detect attempted diversions of special nuclear material. Sharing of this safeguards system information with other nations should result in vastly improved international safeguards levels. Such sharing would appear to be fully consistent with the policy statement of the Act to "actively pursue through international initiatives the establishment of more effective international controls over the transfer and use of nuclear materials...".

Demonstration of the Barnwell safeguards system on a sustained basis in FY-1983, as proposed by the Department of Energy, provides the opportunity for the United States to exert leadership in achieving international agreement on effective and acceptable safeguards for the nuclear fuel reprocessing plants which are being planned, designed, and built throughout the world. This demonstration would be in complete harmony with the Administration's nuclear nonproliferation policy which calls for the United States to help "provide for an improved international safeguards regime and re-establish the United States as a predictable and reliable partner for peaceful nuclear cooperation under adequate safeguards."

5. If you had it within your power and authority to devise a different scheme or organizational format for conducting international and technical safeguards research and development, how would you change the current set-up?

It is our view that an effective scheme for conducting international and technical safeguards research and development should include three key components:

- A comprehensive plan to coordinate the safeguards-related activities which are conducted in the National Laboratories.
- Encouragement of international cooperation in the development of safeguards components and systems.
- Utilization of the unique capabilities of the BNFP as an integral part of the overall plan.

Following conclusion of the International Nuclear Fuel Cycle Evaluation, in May 1980, it was apparent that many nations of the world would proceed with reprocessing, regardless of United States policy. Moreover, participants in the INFCE agreed that improvements in safeguards systems would thus be necessary. The U. S. Department of Energy, through the National Laboratories and other facilities, has subsequently placed increasing emphasis on the development of improved safeguards systems components. This program has drawn on the specialized talents of such national laboratories as Los Alamos, Sandia, Oak Ridge, Brookhaven, and Lawrence Livermore, as well as the DOE-related Rocky Flats, Savannah River, and Hanford facilities. The program has also increasingly drawn on the BNFP and the practical reprocessing operational experience of its staff.

Much of this work on safeguards equipment, as conducted in the United States (and, we believe, elsewhere in the world) has been of high caliber. The BNFP has increasingly been utilized as a facility, unique in all the world, in which to test laboratory-developed concepts in a real, operational environment. The results have been outstanding. Through this cooperative program, the safeguards system which has been installed and tested in portions of the Barnwell Plant, appears capable of accomplishing diversion detection goals which were previously believed unachievable. Tests to date show that this safeguards system would be capable of performing a complete plant inventory once each hour and can detect diversions of as little as 100 grams of special nuclear material. This is a truly significant advance over current safeguards procedures which not only require annual or semi-annual shutdown and cleanout of the reprocessing facility, but also lack the quantitative sensitivity of the Barnwell system. In addition, a Barnwell-developed physical protection system, using state-of-the-art technology, can provide extremely effective controlled access to reprocessing facilities.

Recognition of the BNFP as the focal point for unification and demonstration of advanced safeguards concepts presents an outstanding opportunity for the United States to exert leadership in achieving international agreement on effective safeguards for reprocessing plants to prevent nuclear proliferation. However, international acceptance of this U.S.-developed safeguards system will require demonstration of effectiveness and operability through sustained (two- to three-month) operation utilizing all of the chemical separations components of the Plant as has been proposed by the DOE for FY 1983.

This demonstration will provide the basis for continuing international recognition of U. S. leadership in assuring installation of effective safeguards systems in the reprocessing plants being built, designed, and planned throughout the world.

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August 16, 1982

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2955 George Washington Way
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Dear Dr. Nilson:

We appreciated having you testify on the Exxon Nuclear Company's safeguards research and development programs at the Subcommittee's hearing on August 4, 1982. Chairman Bouquard would like to supplement the record of the hearing with some additional questions regarding the programs. We appreciate your cooperation on this matter and we hope that this information can be provided by September 7, 1982.

If you have any general questions regarding these requests, please contact me at 202/225-8056. If you have any questions regarding the specifics, please contact Dr. Harlan Watson of the Subcommittee staff at 202/225-3472.

Sincerely,

John V Dugan/wjs

JOHN V. DUGAN, Staff Director
Subcommittee on Energy Research
and Production

JVD:wjs
Enclosures

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
CHAIRMAN BOUQUARD'S QUESTIONS ON
TECHNICAL ASPECTS OF NUCLEAR NONPROLIFERATION: SAFEGUARDS
Hearing held August 4, 1982

1. Do NRC personnel accompany the IAEA inspectors, and if so, what other functions do the NRC personnel perform?

2. Are NRC and IAEA inspections coordinated so that both can be done at the same time?

3. What do IAEA inspectors have to say about the instruments they are using?

4. What did you think of the quality of instruments the IAEA inspectors brought with them? Do these instruments need further improvement, and if so, does the U.S. program seem likely to provide it?

5. It was estimated that over 18 months experience, the manpower cost to the company due to the IAEA inspections was less than 0.1% of the fuel fabrication cost. Were there any non-manpower costs involved?

6. It is noted that a remaining deficiency in the measurement and verification of uranium inventories in a low-enriched uranium fuel fabrication plant is the verification of finished fuel assemblies, and that the neutron coincidence collar developed by Los Alamos appears to be a powerful tool in closing this gap.

   a. How much more effort will it take to close this gap?

   b. Will other existing Federal R&D help close it?

7. The suggestion is made that where there is international independence between the fuel fabricator and the power reactor operator, the reactivity tests normally carried out upon reactor startup after fuel loading should provide a useful verification of fresh fuel content.

   a. Does not a reactor operator normally carry out such a verification in order to check the quality of the fuel they are buying and to make sure that the low-enriched uranium they have paid for is really there?

   b. In performing such a verification, is there anything out of the ordinary done in operating the reactor? Would running such a test pose any potential safety problems with a reactor?

   c. Has Exxon discussed this idea with the NRC, and if so, what was their response?

8. It is proposed that consideration be given to supporting safeguards demonstration projects at U.S. plants under IAEA safeguards. Has Exxon proposed such demonstrations to the Department of Energy, Department of State, NRC, or IAEA, and if so, what was the response?

9. If you had it within your power and authority to devise a different scheme or organizational format for conducting international and domestic safeguards research and development, how would you change the current set-up?

10. Please provide the Subcommittee with one copy of each of the following papers which discuss details of Exxon's early experience with IAEA inspection efforts:

    a. Herz, E.R., McGinnes, A.J., and Schneider, R.A., "Initial Experience Under IAEA Safeguards", Proceedings 22nd Meeting of the INMM, July 1981, San Francisco, CA.

    b. Nilson, R., "Initial Experience Under IAEA Safeguards", paper presented at ANS Meeting, San Francisco, CA, November 29-December 3, 1981.

    c. Schneider, R.A. and Herz, E.R., "Implementation of International Safeguards -An Operator's Viewpoint", paper presented at Fifth International Conference on Nondestructive Evaluation in the Nuclear Industry, San Diego, CA, May 10-13, 1982.

EXXON NUCLEAR COMPANY, Inc.
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TELEX: 15-2881

September 3, 1982

Dr. John V. Dugan, Staff Director
Subcommittee On Energy Research
Committee on Science and Technology
U.S. House of Representatives
Suite 2321, Rayburn House Office Building
Washington, D.C. 20515

Dear Dr. Dugan:

My response to your questions of August 16 are attached.

Sincerely,

R. Nilson, Manager
Corporate Licensing

RN:slr

Attachments

AN AFFILIATE OF EXXON CORPORATION

1. Do NRC personnel accompany the IAEA inspectors, and if so, what other functions do the NRC personnel perform?

   Most of the time an NRC inspector accompanies the IAEA inspectors. His function is to observe and to resolve any differences which may arise between the operator and inspector regarding how the inspection should be conducted. (In Exxon Nuclear's experience, such differences of opinion have been few, minor and easily resolved by the NRC inspector.)

2. Are NRC and IAEA inspections coordinated so that both can be done at the same time?

   No.

3. What do IAEA inspectors have to say about the instruments they are using?

   I'm not able to answer for the inspectors; this question should be put directly to the IAEA.

4. What did you think of the quality of instruments the IAEA inspectors brought with them? Do these instruments need further improvement, and if so, does the U.S. program seem likely to provide it?

   The quality is good. In general, no further improvement is needed, but operational simplification could be useful in certain cases.

5. It was estimated that over 18 months experience, the manpower cost to the company due to the IAEA inspections was less than 0.1% of the fuel fabrication cost. Were there any non-manpower costs involved?

   Yes. About 1/2 shift in production time was lost for each of the two inventory verifications. Also, there were some initial, one-time computer costs to modify reporting systems to fit the IAEA format. The non-manpower costs would amount to about a third of the man-power costs quoted in my testimony.

6. It is noted that a remaining deficiency in the measurement and verification of uranium inventories in a low-enriched uranium fuel fabrication plant is the verification of finished fuel assemblies, and that the neutron coincidence collar developed by Los Alamos appears to be a powerful tool in closing this gap.

   a. How much more effort will it take to close this gap?

Considerable additional effort will be needed to effectively incorporate the neutron coincidence collar into the fuel cycle to enable both inventory and flow verifications. Considerable effort will also be needed to complete development, testing and incorporation into the fuel cycle of fuel element seals which must be used in conjunction with the collar. For practical implementation, both these efforts will require in-plant demonstrations involving the assistance of plant operators.

b. Will other existing Federal R&D help close it?

Not that I am aware of.

7. The suggestion is made that where there is international independence between the fuel fabricator and the power reactor operator, the reactivity tests normally carried out upon reactor startup after fuel loading should provide a useful verification of fresh fuel content.

a. Does not a reactor operator carry out such a verification in order to check the quality of the fuel they are buying and to make sure that the low-enriched uranium they have paid for is really there?

Yes, but the main reason is to verify the supplier's calculations of reactivity for safety and fuel life reasons. Indirectly, the tests also provide the verifications posed in your question.

b. In performing such a verification, is there anything out of the ordinary done in operating the reactor? Would running such a test pose any potential safety problems with a reactor?

There is nothing out of the ordinary; this is a standard verification requirement for the reasons cited in answer 7a and does not pose any safety problem.

c. Has Exxon discussed this idea with the NRC, and if so, what was their response?

No, we have never raised this idea with the NRC primarily because it is not important in domestic safeguards. However, the concept was introduced in a paper presented in 1978 at the Atomic Industrial Forum International Conference on Nuclear Non-Proliferation and Safeguards at which both NRC and IAEA Staff were in attendance.

A copy of the paper "Materials Safeguards and Accountability in the Low Enriched Uranium Conversion-Fabrication Sector of the Fuel Cycle" is attached.

8. It is proposed that consideration be given to supporting safeguards demonstration projects at U.S. plants under IAEA safeguards. Has Exxon proposed such demonstrations to the Department of Energy, Department of State, NRC, or IAEA, and if so, what was the response?

   We have discussed such a project with a Staff member of the Arms Control and Disarmament Agency. His response was positive, but any demonstration would be limited by lack of sufficient funding in that Agency.

9. If you had it within your power and authority to devise a different scheme or organizational format for conducting international and domestic safeguards research and development, how would you change the current set-up?

   The organizational format for conducting international and domestic safeguards research and development in the future should include direct inputs to the R&D scoping process from the U.S. nuclear plant operators, both in R&D application engineering in the actual plants and in the technical people assigned by the U.S. government to Agency headquarters in Vienna.

10. Please provide the subcommittee with one copy of each of the following papers which discuss details of Exxon's early experience with IAEA inspection efforts:

    a. Herz, E. R., McGinnes, A. J., and Schneider, R. A., "Initial Experience under IAEA Safeguards", Proceedings 22nd Meeting of the INMM, July 1981, San Francisco, CA.

    b. Nilson, R., "Initial Experience Under IAEA Safeguards", paper presented at ANS Meeting, San Francisco, CA, November 29-December 3, 1981.

    c. Schneider, R. A. and Herz, E. R., "Implementation of International Safeguards - An Operator's Viewpoint", paper presented at Fifth International Conference on Nondestructive Evaluation in the Nuclear Industry, San Diego, CA May 10-13, 1982.

    Copies of the requested papers are enclosed, as is the paper referred to in Answer 7C.

MATERIALS SAFEGUARDS AND ACCOUNTABILITY IN THE LOW ENRICHED URANIUM CONVERSION-FABRICATION SECTOR OF THE FUEL CYCLE

by

R. Nilson, R. A. Schneider, and J. L. Jaech
Exxon Nuclear Company, Inc.

Presented at the International Conference on
Nuclear Nonproliferation and Safeguards,
Atomic Industrial Forum

New York City, New York

October 24, 1978

MATERIALS SAFEGUARDS AND ACCOUNTABILITY IN THE LOW ENRICHED URANIUM CONVERSION-FABRICATION SECTOR OF THE FUEL CYCLE

R. Nilson, R. A. Schneider, and J. L. Jaech
Exxon Nuclear Company, Inc.

INTRODUCTION

Today materials accounting in the low enriched conversion-fabrication sector of the LWR fuel cycle is of increased importance. Low enriched uranium is rapidly becoming a precious metal with current dollar values in the range of one dollar per gram comparing with gold and platinum at 7-8 dollars per gram. In fact, our production people argue that its dollar value exceeds its safeguards value. Along with this increased financial incentive for better material control, the nuclear industry is faced with the impending implementation of international safeguards and increased public attention over its ability to control nuclear materials. Although no quantity of low enriched uranium (LEU) constitutes a practical nuclear explosive, its control is important to international safeguards because of potential misuse by a national capability via plutonium production or further enrichment to an explosive grade material.

I am here today to examine and discuss some factors in the area of materials safeguards and accountability as they apply to the low enriched uranium conversion-fabrication sector. Our paper treats four main topics: (1) basis for materials accounting; (2) our assessment of the proposed new IAEA requirements; (3) adequacy of current practices; and (4) timing and direction of future modifications.

BASIS FOR MATERIALS ACCOUNTING

Currently, materials accounting is the principal safeguards measure for low enriched uranium. It is based on the intrinsic value of the material, fuel manufacturing needs, national and international safeguards requirements, and the need to provide assurance that material control measures have been effective.

Dollar Value

The current dollar value for low enriched uranium (LEU) is shown in Slide 1 (excluding any added value contributed by fuel fabrication). The values are based on natural uranium at $42 a pound of U_3O_8, separative work at $75 a SWU, and standard U_3O_8-UF_6 conversion costs.

It is apparent from the dollar values for either kilograms of low enriched uranium or grams of U-235 contained that real financial incentives exist for good material control. For example, the value of a typical fuel pellet is $10. Thus, of particular importance is the cost incentive for waste loss reduction and improvements in waste recovery. These programs are also basic to improved safeguards performance since they often lead to significant reductions of the plant MUF and LEMUF. The high monetary value also provides a very strong incentive for close material control of an extremely valuable asset.

Fuel Manufacturing Needs

At LWR fuel conversion-fabrication plants, a high degree of material control and accountability is required for purposes of criticality safety, quality and process control, production control, and contract performance. These needs are not new but need mentioning for completeness, and the fact that they exist represents important adjuncts to safeguards which are inherent in the fuel fabrication business.

Safeguards Requirements Imposed by Authorities

Safeguards accountability requirements for U.S. plants stem from Title 10, Part 70 of the Code of Federal Regulations. Those for Euratom

CURRENT VALUE OF LOW-ENRICHED URANIUM

Wt. % U-235	$/Kg U	$/Gram of U-235 Contained
1.0	206	21
1.5	380	25
2.0	563	28
2.5	751	30
3.0	943	31
3.5	1136	32
4.0	1332	33
4.5	1529	34
5.0	1726	35

SLIDE 1

countries arise from the Regulations of the Commission of the European Communities concerning Euratom safeguards. The pertinent IAEA safeguards agreement is the Agreement between IAEA and those States on safeguards under NPT. That agreement is covered in IAEA Information Circular 153 commonly referred to as the "Blue Book."

The common requirements for materials accounting and safeguards from these three safeguards authorities are shown in Slide 2. The requirements shown apply generally to all bulk handling facilities. Thus, all operators of bulk handling facilities are required to:

1. Measure all quantities of nuclear material received, shipped, discarded, and on inventory;
2. Maintain a formal accounting system for recording all internal and external transactions;
3. Conduct physical inventories;
4. Maintain material control areas;
5. Provide to the safeguards authorities reports of all external transfers, material status reports, and all usual events or discrepancies;
6. Maintain a measurement control program for estimating and controlling measurement errors; and
7. Provide for audits, verification activities, and performance evaluation by safeguards inspectors.

The requirements for materials accounting for low enriched uranium, which is not a strategic special nuclear material (SSNM), differ sharply in degree but not in kind from those required for plutonium or other

GENERAL REQUIREMENTS

- Measurement of All Quantities
- Records of All Transactions
- Physical Inventories
- Mass and Item Control Areas
- Reports of Transactions, Status, and Discrepancies
- Measurement Control Programs
- Audits, Evaluation, and Verification by Safeguards Inspectors

SLIDE 2

SSNM. The main differences in degree are in the areas of timeliness and intensity of internal control measures. There are also some differences in the requirements of the three safeguards authorities which I will discuss briefly later.

The bottom line with regard to materials accounting requirements for low enriched uranium is that a high quality measurement and accounting system is required.

Assurance to the Public

A very important objective of materials accounting is providing continual assurance to the public that materials control measures are effective; that is, assuring that quantities of low enriched uranium which are judged to be of safeguards importance have not been lost or could not be lost without a positive indication from the accounting data. This objective is of particular importance because difficulties exist in public differentiation between safeguards significance of low enriched uranium and high enriched uranium; to the public, uranium is uranium.

A plant operator measures his ability to provide this form of assurance by his MUF and LEMUF. The plant LEMUF is a measure of the capability of the measurement and accounting system to distinguish loss from measurement uncertainty. For example, if the calculated LEMUF is small compared to a quantity of LEU that is judged to be of safeguards importance, then there is a high degree of assurance that the loss of a quantity of LEU of safeguards importance would not go unnoticed upon completion of a material balance.

MUF performance can be judged by comparing the observed MUF to both the LEMUF and to a quantity of LEU of safeguards importance. It is the sum, MUF plus LEMUF, which represents the upper end of the interval in which the "true" MUF lies,[1] and hence, attention should be focussed on this sum as well as on the two components of the sum.

ASSESSMENT OF REQUIREMENTS

The common elements of material accounting requirements under NRC, Euratom, and IAEA safeguards were shown earlier. Although the basic elements are much the same, there are important differences in the safeguards objectives of those safeguards authorities. Under NRC safeguards for low enriched uranium conversion-fabrication plants, safeguards reliance has been placed primarily on the plant operator's accountability data. Substantiation or verification activities in the LEU sector by NRC inspectors have been centered largely on the quality of the licensee's measurements rather than on the direct verification of quantities in inventory or quantities of flow. By contrast, under Euratom and IAEA safeguards, the emphasis is placed on the direct substantiation or verification of the plant operator's data by the safeguards authority. As a result, both Euratom and IAEA safeguards requirements include provisions to facilitate quantitative verification. The special requirements for such verification are shown in Slide 3.

Before discussing these requirements and their impact on plant operations, it should be noted that the added requirements do not apply in the same manner to all plants. Plants under IAEA safeguards in non-weapon countries need to meet all the requirements, whereas plants in nuclear weapon states coming under "voluntary programs" may be affected differently. For example, under the proposed U.S.-IAEA agreement, all plants in the U.S. on the eligible list would come under the general reporting requirements. However, not all U.S. plants will be subject to inspection at any one time. As a result, the need to provide advance notification and to provide for inspection activities is required only during the time period for which a particular U.S. plant is under inspection.

The reporting aspects of the requirements for verification, although they involve an extra coordination effort, should not in themselves be a major burden. The requirement for advance notification will be,

SPECIAL REQUIREMENTS FOR QUANTITATIVE VERIFICATION

- Reporting by Batch Designations
- Reporting of Physical Inventory by Stratum and Batch
- Advance Notification of Imports, Exports, and Inventory Times
- Provision for Verification Activities

SLIDE 3

however, of concern to both the operator and the inspector. The operator is concerned that the advance notification requirement for exports or imports will become a production commitment such that he might have to slow or stop production to meet a previously made verification date. The inspector is concerned with having ample advance notice to arrange his inspection schedules or having to rearrange inspection schedules in the case of plant delays or requests for the inspector to arrive earlier than the date of advance notification to accommodate plant production changes. It is apparent that a high degree of cooperation and coordination will be necessary. In some cases, special arrangements between the operator and the inspector may be the most practical solution.

The other areas of impact are the verification activities themselves for which there is as yet little U.S. experience. Our comments are based primarily on initial discussions with IAEA and Euratom safeguards staff members. In the low enriched conversion fabrication sector of the fuel cycle, we anticipate both types of verification activities--flow verification and inventory verification. We assume that flow verification will consist of random on-the-spot verifications of imports and exports. We expect that verification of imports would take place shortly after receipt of the material and for exports just prior to packaging.

We expect that inventory verification at LEU conversion-fabrication plants would become an integral part of the operator's annual or semiannual inventory. We envision a two-step process. First, the operator completes his inventory and reconciliation and then the inspector carries out his verification sampling plan with the assistance of the operator in moving items selected in the sampling plan for verification measurements such as NDA testing, weighing, or sampling. With the exception of measurements made using the inspector's equipment, the operator would perform all the measurements under the observation of the inspector. The operator would also perform all material handling functions and packaging of samples for shipment to a safeguards laboratory. Our understanding is that at least some of these costs will be borne by the IAEA.

Both flow and inventory verification activities can have a significant impact on plant operations. Hopefully, the cost impact can be minimized by suitable practical arrangements.

It is also apparent that successful verification requires the active cooperation of both the operator and the inspector. The basis for such a cooperative effort is provided for in the governing enactments which make the operator a party to all discussions relating to verification at his facility. Article 8 of the Euratom Regulations provides for consultations with the operator prior to determining the "particular safeguards provisions." Under IAEA safeguards, the plant operator is a party to the discussions of the Facility Attachments which include the detailed arrangements for verification.

Our initial experience in such discussions has been quite favorable, both in Europe and in the U.S. We found in our case that the plant operator is indeed a true party to such discussions. We also found our inspectors to be knowledgeable, practical, and reasonable.

Here in the U.S., where international safeguards activities will be a completely new experience, a number of concerns[2] have been expressed over the implementation of IAEA safeguards. Some of these concerns I have discussed earlier. Additional concerns include the question of protecting commercially sensitive information, whether more than one MBA per facility will be required for IAEA reporting, and the logic of batch designations for flow and inventory reporting. These concerns have not been fully resolved in our minds as yet; but we are confident that as we continue to interact with NRC and IAEA representatives, continued progress can be made in easing them.

During the past year, certain licensees, including ourselves, have participated in an exercise on the implementation of IAEA safeguards under a joint program by NRC and IAEA. Our exercise consisted of the preparation, submittal, and IAEA review of a Design Information Questionnaire and the co-preparation of a Facility Attachment by the IAEA, NRC, and ourselves for our LEU conversion-fabrication plant in Richland, Washington. Currently, we are in the last stages of the Facility Attachment part of the exercise. In our opinion, the completion of the Design Information Questionnaire is equivalent in effort to the preparation of a Fundamental Material Control Plan. For our LEU fuel assembly plant located in Lingen, Germany, our progress (except for the verification section of the attachment) has been similar, with Euratom in the role of the Community inspector.

We and other licensees have also participated in a session on material type codes for converting plant codes to the IAEA coding system. We understand that conversion from plant material type codes to IAEA material type codes will be done by computer on the Nuclear Materials Management and Safeguards System at Oak Ridge. We heartily endorse that effort.

ADEQUACY OF CURRENT PRACTICES

A continuing question is: "are the current safeguards accountability practices in the LEU-conversion-fabrication sector adequate for safeguards?" If we could answer this question from a purely domestic point of view, our answer would be a resounding yes. That answer would be based primarily on the argument that no quantity of low enriched uranium currently constitutes a safeguards risk in the context of its use as starting material in the direct preparation of a nuclear explosive.

Unfortunately, one cannot separate purely domestic from international safeguards concerns since the consequences of national misuse can

EXAMPLE ANALYSIS OF THE POWER TO DISTINGUISH LOSS FROM MEASUREMENT UNCERTAINTY FOR A LEU PLANT

Annual Plant Throughput			Probability(1) of Loss Exceeding LEMUF		
			Loss, Kgs U-235		
Tonnes U	Kgs U-235	% U-235 LEMUF	125	250	500
400	12,000	0.50	.98	>.99	>.99
800	24,000	0.50	.53	.98	>.99
1,200	36,000	0.50	.27	.78	.99

---

(1) Probability of the observed loss (MUF) exceeding LEMUF if true loss is as indicated.

SLIDE 4

EXAMPLE ANALYSIS OF THE POWER TO DISTINGUISH LOSS
FROM MEASUREMENT UNCERTAINTY FOR LEU SECTOR

Annual Sector Throughput		Sector	Probability[1] of Loss Exceeding LEMUF		
			Loss, Kgs U-235		
Tonnes U	Kgs U-235	% U-235 LEMUF	125	250	500
2,000	60,000	0.224	.44	.96	>.99
4,000	120,000	0.224	.14	.44	.96
6,000	180,000	0.224	.08	.22	.68

---

[1] Probability of the observed loss (MUF) exceeding LEMUF if true loss is as indicated.

SLIDE 5

impact on all inhabitants of our earth. As a result, to evaluate adequacy one must consider quantities of LEU which are judged to be important from an international standpoint. For given quantities of LEU of safeguards importance, it is possible to evaluate the ability of materials accounting to distinguish between loss and measurement uncertainty. Two examples of this type of analysis are shown in Slides 4 and 5; one for a single plant and one for a LEU conversion-fabrication sector (i.e., a group of plants).

To perform the example analysis, we assumed that the U-235 LEMUF for an individual plant is equal to the NRC limit of 0.5 percent of throughput. For the LEU sector case, we assumed five plants of equal throughput and assumed the measurement systems to be truly independent such that propagated LEMUF for the five-plant sector is 0.224 percent of throughput or a relative reduction of the square root of five for the individual plant LE's of 0.5 percent (i.e., $0.5/\sqrt{5}$). In both cases, the average enrichment processed is assumed to be three weight percent U-235.

Since we do not believe that it is possible to sharply define the quantity of LEU which is of safeguards importance, we chose a range of values for kilograms of U-235 contained to correspond to multiples of five, ten, and twenty times the approximate fast critical mass of high enriched uranium;[3] that is, multiples of 25 kgs of U-235 contained. This value compares to an IAEA value for evaluation purposes of 75 kg contained U-235[3] and 5 ekg (167 kg U-235 at three percent U-235) from a recent INMM Safeguards Committee study.[4]

It is further assumed that a central safeguards authority such as IAEA would evaluate the observed MUF of an individual plant versus its LE and the observed MUF of the LEU sector of a state against the propagated LE of the sector as part of the battery of tests used by them for safeguards evaluations.

Slide 4 for a single plant illustrates the power of loss distinction as a function of throughput and as a function of the assumed quantity of safeguards importance. The probability in the last column is the probability of the observed MUF exceeding its LE given that the loss of a quantity of safeguards importance has occurred. To place the probabilities in better perspective, it should be noted that the probability of an observed MUF exceeding its LE is 0.50 at the point where the true loss is equal to the LE which is the trigger point for investigation. Thus, in Slide 4, probabilities exceeding 0.5 indicate that the accounting system is adequate to signal a loss of the assumed quantity of safeguards importance. The "success zone" is marked in the tables.

Slide 5 shows similar information as Slide 4, but this time for an assumed LEU sector of five plants of equal throughput and having equal but independent LEMUF's of 0.5 percent per plant such that the relative LEMUF of the sector taken as a whole is 0.224 percent of throughput as discussed previously.

Assuming that the range of values chosen for safeguards loss distinction goals are realistic and that LEMUF values are upper limit values, it can be concluded from the examples that materials accounting can indeed provide an adequate degree of safeguards assurance. Obviously, assuming lower LEMUF values and higher loss distinction goals would provide even higher probabilities. But if one includes the mid-range probabilities, even they are for the most part in a useful range of loss distinction.

Of equal importance is the timeliness of the accountability system in detecting apparent losses of safeguards importance. In safeguards systems analysis, the concept of critical time is often used in determining the required frequency of physical inventory taking or material balance closing. The critical time is defined as the time required to convert a given type of nuclear material into a nuclear explosive.

For low enriched uranium, it is not possible to sharply define the critical time because of the long and complex nature of the processes leading to SSNM and the complexity of the assumptions regarding the capabilities of the assumed diverter. For international safeguards, this time has been estimated to be in the order of one year[3] to two years.[4] Thus, to meet the lower estimate of critical time, a plant operator would need to have either some form of continued assurance that quantities of safeguards importance are not missing or else take physical inventories more frequently than once a year. We believe the current NRC requirement of six month cleanout inventories or their equivalent to be adequate. More frequent "tag value" (i.e., no cleanout) inventories could be of some benefit in detecting trends and in providing early warning. However, the benefit of tag inventories for conversion areas is seriously limited by the magnitude and variability of equipment holdup. In some cases quarterly cleanout inventories may be the best compromise between inventory quality and timeliness.

We do not believe that real time materials accounting is required for safeguards assurance in the LEU conversion-fabrication sector. Real time accounting is similar in benefit to frequent (monthly or bimonthly) tag inventories and suffers from the same deficiencies such as the inability to measure equipment holdup. To some extent, the computer-based accounting systems used in the LEU conversion fabrication sector approach real time accounting. In some instances, book values for material balance areas and item listings for item control areas are maintained on a daily basis. Such features ease the taking of inventories and reduce the costly nature of frequent inventory taking. However, as yet there does not appear to be any practical substitutes for physical inventories accompanied by equipment cleanouts in the low enriched conversion-fabrication sector. If the size of hidden inventory buildups due to equipment holdup could be realistically modeled as a function of time, then the major deficiency of tag inventories (e.g., variable holdups) would be eliminated and tag inventories would then take on added value as a safeguards detection tool. Our experience with monthly MUF's is that such modeling is generally not possible in the LEU conversion-fabrication sector.

The last and most difficult aspect of adequacy is the actual demonstration by MUF performance that important quantities of LEU could not have been lost. Because of a historical positive MUF trend of the industry, the demonstration of adequate MUF performance (MUF → 0) is a difficult task facing the nuclear industry today. Although we are convinced that most of the positive MUF trend can be explained by the underaccounting of liquid and solid wastes due to waste measurement problems, an explained MUF is no substitute in credibility for good actual MUF performance. A current indication of the positive MUF trend in all major U.S. plants is shown by the low enriched uranium inventory difference values reported in NUREG 0430[5] which covers fiscal year 1977.

TIMING AND DIRECTION OF FUTURE MODIFICATIONS

Areas of Improvement

We believe that there are remaining areas where cost-effective improvements can be made in safeguards materials accounting practices in the LEU conversion-fabrication sector. These are in the areas of MUF performance, loss distinction, and safeguards emphasis.

As was noted earlier, the nuclear industry is faced with a common positive MUF trend. Based on our experience, we believe that this trend is primarily due to the underaccounting of solid and liquid wastes. At the current high dollar value of low enriched uranium, there is increased incentive for waste reduction and recovery programs and for improved waste measurement systems which should alleviate some of these problems.

We have carried out a number of solid waste recovery experiments and liquid waste measurements to verify or improve our own waste measurements. From these experiments and results of modifications, we have become convinced that our MUF performance is directly related to our ability to reduce the level of uranium going to waste and/or improvements in our waste measurement systems. We and other West Coast licensees are also currently engaged in a solid waste measurement experiment with the Battelle-Northwest Laboratories under the sponsorship of NRC in which various NDA systems are being evaluated. Part of the experiment involves a comparison between chemical recovery and NDA values. Results are as yet tentative, but there are indications that biases in NDA systems for measurement of solid waste can be quite significant. A major part of this problem lies, in our opinion, with developing realistic calibration standards, a problem that is difficult to solve.

In the LEU conversion-fabrication sector of the U.S., a significant gain in the sensitivity of loss distinction can be made by changing from the traditional emphasis of U-235 MUF to U element MUF. We estimate that a gain of about 40 percent may be achieved by such a change of emphasis. For MUF accounting in LEU conversion-fabrication plants, the enrichment does not play a critical role since the enrichment of fuel materials cannot be changed except by blending. The adding of the enrichment measurement errors to the measurement errors associated with determining quantities of uranium element creates an additional measurement component uncertainty in U-235 accounting which is not essential in detecting material loss. (The use of U-element MUF and LEMUF will not in any way eliminate the need for the nuclear industry to maintain high quality enrichment measurements to detect substitution scenarios and to provide best "state-of-the-art" enrichment values for material going into reactors.)

A suggested way for changing the loss distinction emphasis to U element and still retain the same control for U-235 would be to have two LEMUF limits, one for the U LEMUF and one for enrichment LEMUF or that part of the U-235 LEMUF which arises solely from the enrichment measurement errors.

Based on our experience that the variances for U element and enrichment measurement error are about equal, a suggested approach would be to set the limit for both U LEMUF and enrichment LEMUF at 0.35 percent of throughput. The propagated combined U LEMUF and enrichment LEMUF is then equal to the current U-235 LEMUF, since the root mean square of 0.35 and 0.35 yields the current NRC limit of 0.5 percent for the U-235 LEMUF.

The gain in loss distinction sensitivity for this change in emphasis is shown in Slide 6 for one of the single-plant cases discussed earlier. Now, in this example, all loss distinction probabilities are above 0.5 (i.e., in the "success zone").

In recent years we have observed a U.S. regulatory trend toward placing a greater emphasis on internal MUF's and the isolation of loss by individual internal material control areas. We believe that these objectives of greater internal control should be deemphasized with respect to the more important safeguards objective of "zero" MUF across the total plant. We believe that it is far more important to spend available efforts on controlling and improving the overall plant MUF than in trying to reduce to zero the inherent "paper" MUF's which arise between two adjoining MBA's which often involve a large number of transactions in both directions. We believe that the most important indices of safeguards performance in the LEU conversion-fabrication sector are the periodic and cumulative plant MUF's.

External Checks and Balances

With the advent of international safeguards in the U.S., we expect to see a greater emphasis placed on the safeguards position of fuel

EXAMPLE OF GAIN IN POWER OF LOSS DISTINCTION
BY USE OF U LEMUF VERSUS U-235 LEMUF

Annual Plant Throughput			Probability[1] of Loss Exceeding LEMUF		
			Loss, Kgs U-235		
Tonnes U	Kgs U-235	% U-235 LEMUF	125	250	500
800	24,000	0.5	.53	.98	>.99[2]
		% U-LEMUF			
800	24,000	0.35	.84	>.99	>.99

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[1] Probability of the observed loss (MUF) exceeding LEMUF if true loss is as indicated.

[2] From Slide 4.

SLIDE 6

fabrication in the fuel cycle and on the external checks on the output of fuel fabrication.

In the LWR fuel cycle, conversion-fabrication plants play an important part in the overall safeguards plan by their position in the fuel cycle. First, as fuel receivers of the output of enrichment plants, they provide an independent check on accountability statements made on the enrichment plant's product shipments. As the fuel supplier to the reactor, they provide, through their measured values for uranium element and enrichment, the basis for computing plutonium production. The initial values measured at fuel fabrication when corrected for reactor burnup can also provide important safeguards verification cross-checks if the spent fuel is eventually reprocessed.

We also expect to see a greater emphasis in the future on establishing cross-checks and means of protecting the integrity of the product measurements made at fuel fabrication. We believe that the fuel supplier has capability to provide "best state-of-the-art" measurements for his product shipments. The inspector by contrast, is currently severely handicapped in his capability to verify the output of fuel fabrication and to verify that the integrity of the fuel has been maintained as it goes from the fuel plant to the reactor and later to fuel storage and/or reprocessing.

Currently, it is technically feasible for the inspector to verify the output of fuel fabrication up through the rod loading process. With the general use of fuel rod assay units, it is technically possible to verify the contents of loaded rods to a fair degree of exactness. However, once the fuel bundle is assembled, the inspectors' capability to verify is severely limited.

We should note that LASL is currently active in developing NDA instruments for verifying the contents of assembled fuel bundles. We plan to assist them in performing some of the experiments at our fuel fabrication plant in Richland.

We are also engaged in a cooperative program with Euratom Safeguards and the Sandia Laboratories in the development of seals for fuel assemblies. The seal approach has great promise in that it could allow the inspector to obtain assurance that his initial verification of fuel content at fuel rod loading is maintained through the later stages of the fuel cycle until the fuel assembly is discharged from the reactor and shipped to its ultimate destination.

An additional and possibly routine overcheck on the output of fuel fabrication is provided by the reactor in terms of the startup reactivity tests made after fuel loading for safety evaluation. The effect of an off-standard fuel loading would be seen in physics testing experiments conducted for reactor safety purposes during startup after fuel loading. A shortage of U-235 would give a lower reactivity than expected. For example, if our lower quantity of safeguards importance (125 kilograms of contained U-235) were missing from a 30 tonne reload of three percent enriched uranium, the reactivity would be more than one percent lower than expected. A difference this large is detectable in the reactor and would, of course, be of serious concern to the reactor operator. An off-standard fuel loading may also be seen to some extent in the reactor's radial power distribution. As yet, we have not had an opportunity to evaluate the safeguard potential of these kinds of crosschecks in a quantitative way, but they may offer a good overall crosscheck for diversion of significant quantities of safeguards importance.

SUMMARY

In summary (Slide 7), any safeguards risk of low enriched uranium arises from considerations of national misuse rather than its potential use by small subnational groups or individuals. The international hazard of low enriched uranium is generally not well recognized by the plant operator; the risk, if any, is remote and distant. The high monetary value of low enriched uranium provides the plant operator with a more concrete incentive for good accountability measures.

SUMMARY OF IMPORTANT POINTS

- LEU Important From International Viewpoint Only
- High Monetary Value Provides Incentive for Improved Control
- Verification Requires Cooperative Effort
- Current Accountability Practices Adequate for Safeguards
- Improvement of MUF Trend by Better Waste Control and Waste Measurements
- Improved Sensitivity with U-MUF and U-LEMUF
- Future Direction: Plant MUF and CUM MUF; Safeguards Fuel Cycle Cross-Checks; and Verification of Fuel Fab Plant Product

SLIDE 7

The implementation of international safeguards which will have only modest impact on the low enriched uranium sector in the U.S. requires the verification of material quantities by safeguards inspectors. The cooperation of both the operator and the inspector will be essential to the success of these activities.

The safeguards role of materials accounting in the LEU conversion-fabrication sector is to provide assurance that quantities of LEU of safeguards importance are not missing. Current practices are sufficiently timely and have good power of loss distinction to provide adequate assurance.

Based on one year's data, the low enriched uranium conversion-fabrication industry has a common positive MUF trend which unfortunately can be misused to reduce the safeguards credibility of the industry. We believe that this common positive MUF is due in large part to under-accounting of liquid and solid wastes and improvements in these areas are judged to be cost-effective and should be evaluated.

The sensitivity of loss distinction can be improved by placing the safeguards emphasis on the U-element MUF and U LEMUF rather than on the U-235 MUF and U-235 LEMUF as is currently done in the U.S.

We recommend that the future direction of materials accounting safeguards in the LEU conversion-fabrication sector places a greater importance on the total plant MUF and the cumulative plant MUF than on the internal MBA structure. For international safeguards, the role of conversion-fabrication plants as part of a safeguarded fuel cycle will receive greater emphasis.

Research and development efforts for international safeguards are being directed at closing the final product verification deficiency which currently exists in fuel fabrication plants. Fuel assembly seals, NDA devices, and reactor reactivity tests all hold promise of improving that situation.

REFERENCES

1. Jaech, J. L., Statistical Methods in Nuclear Material Control, TID-26298, 1978.

2. Letter from George H. Stathakis, Chairman, AIF Committee on International Fuel Policy to the Commission, dated July 24, 1978.

3. IAEA Safeguards Technical Manual, Part A, Principles, IAEA-174, 1976.

4. Wilson, D. H., et. al., "Assessment of Domestic Safeguards for Low-Enriched Uranium," INMM Ad Hoc Writing Group of the Safeguards Committee, August 1976. Special Report of the Journal of the Institute of Nuclear Materials Management.

5. "Licensee Fuel Facility Status Report," NUREG 0430, Volume 1, No. 1, Nuclear Regulatory Commission, May 1978.

INITIAL EXPERIENCE UNDER IAEA SAFEGUARDS

By

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ABSTRACT

Exxon Nuclear's low enriched uranium fuel fabrication plant is the first U.S. bulk handling facility selected for IAEA inspection under the US/IAEA Agreement which went into effect on December 9, 1980. Initial efforts to meet the requirements of IAEA safeguards implementation included preparation of the Design Information Questionnaire (DIQ), reporting of the initial book inventory, preparing to accommodate an IAEA Ad Hoc inspection to verify our initial inventory report, and planning for discussions of a Facility Attachment. Later activities included packaging and shipping IAEA verification samples, reporting inventory changes on the new 741 forms, reporting material status and the physical inventory listing (PIL) on the new 742 forms, and providing a basis for advance notification on exports, imports, and domestic shipments to "non-eligible destinations".

This paper describes our initial experience under IAEA safeguards. The paper emphasizes the extent to which we were able to suggest and develop practical approaches for verification of material quantities and for meeting the various reporting and notification requirements.

INTRODUCTION

The United States, as a party to the Non-Proliferation Treaty (NPT), has joined with other nations in an effort to limit the spread of nuclear weapons. To encourage widespread adherence to the NPT by non-nuclear-weapon states, President Johnson in 1967 announced that the United States would permit the International Atomic Energy Agency (IAEA) to apply its safeguards to nuclear activities in this country. This policy has been reaffirmed by each succeeding president.

The formal agreement between the U.S. Government and the International Atomic Energy Agency for applying IAEA safeguards in the United States was ratified by the U.S. Senate on July 2, 1980. The Nuclear Regulatory Commission (NRC) published its final rule (10 CFR 75) on July 31, 1980, providing the means by which the Agreement is to be implemented. Finally, on December 9, 1980, the US/IAEA Agreement was entered into force. On February 17, 1981, the NRC notified Exxon Nuclear that it had been chosen by the IAEA as the first U.S. bulk handling facility to come under the full safeguards agreement. We expect to be under IAEA safeguards for approximately two years, at which time the Agency is expected to select other facilities for inspection.

INITIAL ACTIVITIES

Upon notification of our selection for Agency safeguards by the NRC, various actions were initiated to meet the requirements of full implementation of IAEA safeguards.(1) The first of these actions was to update the Design Information Questionnaire (DIQ), which Exxon Nuclear had originally prepared in 1977 as part of a voluntary NRC-IAEA program on IAEA safeguards implementation under the then proposed US/IAEA Agreement. An example Facility Attachment was also prepared under the voluntary program.

The completion of the 1981 DIQ was greatly facilitated by having available the 1977-prepared DIQ.(2) Although both the Exxon Nuclear facilities and the DIQ questions had changed considerably since 1977, much of the original text was retained. Current information from the Fundamental

Nuclear Material Control (FNMC) document was also incorporated directly in the updated DIQ. However, extensive transfer of FNMC information into the DIQ, though seemingly logical, was not practical since the scope and philosophy of the two documents are different. Even so, future revisions of the DIQ and FNMC may be prepared in parallel.

Facilities expected to come under IAEA safeguards in the future may wish to begin preparing the DIQ (or updating a previously-prepared DIQ), before the official notification of selection for IAEA safeguards is received. It is very difficult to fully prepare a quality DIQ and obtain the necessary internal reviews and approvals in the time allowed by the NRC. Our experience shows that the initial preparation of the DIQ is a major undertaking which can consume one man-year of effort including accumulating and sorting information, writing and typing the text, and obtaining reviews and approvals. Even updating an earlier DIQ required considerable effort; in our case about two months of continuous effort by one person.

Instructions for preparing the DIQ indicate that the printed DIQ Forms should be used.(1) However, we found it much simpler to complete the DIQ in the form of a controlled Company document. In this manner, a section of the text could be devoted to each question and any necessary tables and figures included in that section. Further, copy distribution inside and outside of Exxon Nuclear, as well as procedures for revised pages, could be more effectively handled by using our internal document control procedures.

An initial book inventory report was also required(1,3) for submission to the NRC on DOE/NRC Form 742 as of February 28, 1981. This information was provided for each material type, by updating our September 1980 physical inventory for the quantities of element and isotope shipped and received, to reflect the book balance as of February 28, 1981.

The final activities undertaken by Exxon Nuclear during this initial phase was preparing for a visit at the end of March 1981 by five IAEA inspectors and six additional personnel from the U.S. Government and one NRC consultant from Battelle-Northwest. The purpose of their visit was to get acquainted with Exxon Nuclear personnel and facilities, to perform an Ad Hoc inspection (verification) of our March 1981 physical inventory, and to initiate discussions of the Facility Attachment. Pre-visit actions by Exxon Nuclear included: 1) reporting to the NRC in advance the date of our March 1981 physical inventory; 2) preparing an itinerary of the IAEA inspection for management; 3) discussing with IAEA and NRC approaches for verifying our UF_6 and fuel rod inventory; 4) overseeing the customs requirements and transport of special IAEA non-destructive assay (NDA) equipment to Exxon Nuclear from abroad; 5) preparing a document describing our physical inventory procedures; and 6) summarizing our inventory by strata to facilitate IAEA sampling and verification plans.

MARCH 1981 IAEA VISIT

The first Ad Hoc IAEA inspection of our U.S. fuels fabrication plant was conducted by five IAEA inspectors from March 25 to April 1, 1981. The scope of the initial inspection included the following:

1. Reviewing our physical inventory procedures;
2. Presenting the IAEA objectives for verification of the physical inventory;
3. Observing our taking of the physical inventory;
4. Verifying the total item count in selected areas;
5. Applying random sampling plans to the main inventory strata to select items for independent verification;
6. Performing independent measurements, witnessing remeasurements performed by our technicians, and witnessing the taking, packaging, and sealing of samples to be sent to Vienna;

7. Witnessing our initial inventory reconciliation effort; and
8. Discussing the Facility Attachment.

Items selected for independent measurement by the IAEA included UF_6 cylinders, fuel rods, powder buckets, pellet trays and boats, scrap buckets, and waste barrels. The basis for the sample sizes was a planning goal quantity of detecting losses of 75 kilograms U-235 by "gross defects" for each stratum sampled.

The contents of four out of eleven full UF_6 cylinders on inventory were verified by observing reweighing of the cylinders, by making enrichment measurements with a GeLi detector, and by using an ultrasonic meter to measure cylinder wall thicknesses. The GeLi detector was calibrated for relative response using three powder samples of varying (but known) enrichments which were prepared by Exxon Nuclear specifically for that purpose. To help convert the NDA enrichment measurements of the cylinders to absolute values, a sample (for IAEA mass spectrometer analysis) of one of the cylinders was taken from the hydrolysis tank when the cylinder was processed.

Forty-five fuel rods out of a population of 14,000 were verified using the IAEA gamma ray counter (SAM-2) and also our active rod scanner. Two (full length) reject rods were used as scanner standard rods to match 35 of one rod type and 8 of another rod type in the IAEA random sample. To convert the relative values to absolute and independent measurements, the two standard rods were "down loaded" (the rods are cut open and all pellets are removed) for weight verification and sampling of the pellets for IAEA destructive analysis.

Thirty-eight powder and eight scrap buckets were verified by observing our reweighing, measuring each bucket on our SAM-2 for enrichment, and sampling ten of the buckets for destructive analysis.

Pellets were verified by observing reweighing and taking pellet samples for destructive analysis. In this stratum, 75 pellet trays and one pellet boat were reweighed for the IAEA and eight pellet samples were taken.

Three solid waste barrels were selected by the IAEA and remeasured using our waste assay counter. Two standard barrels were remeasured also.

Several innovative approaches were developed during the inspection for more cost-effective verification. For example, it was possible to reduce the IAEA's original sample size of forty-six destructive analysis samples for powder and scrap to ten samples by substituting an enrichment meter (SAM-2) attribute test for each bucket to detect a gross defect. This approach saved both IAEA and Exxon Nuclear personnel a considerable amount of time and effort, since verification with a SAM-2 is many times faster than sampling, and does not require the constant attention of material handling technicians.

Similarly, the first approach considered by the IAEA for fuel rod verification was to scan selected rods with their SAM-2, and for Exxon Nuclear to prepare, from leftover pellet and cladding stocks, several short "rodlets" for use as SAM-2 standards and to obtain pellet samples for destructive sampling. The IAEA had originally considered having rodlets prepared, each of a different enrichment and for each unique cladding and pellet size used by Exxon Nuclear. Because of the many different pellet-cladding sizes and enrichments in our inventory, and the logistics in collecting the needed materials and preparing the rodlets, this approach was not practical. As an alternative, we suggested that the IAEA use rejected production rods as standards, and to download those rods for sampling and destructive analysis. This suggestion and the IAEA suggestion for use of our rod scanner on a non-priority basis were adopted as the final concept. This approach was enthusiastically received, since it was more accurate, faster, and much less costly than the original plan.

There was an initial misunderstanding on just what inventory data were needed immediately by the IAEA to check our inventory count of items and the "protocol" for us providing such data directly to the IAEA rather than through the U.S. Government. The problem was resolved by providing copies of the physical inventory sheets and other inventory data summaries to the IAEA on a provisional basis, thereby allowing the inspection to proceed. Additionally, we did not fully anticipate the magnitude and scope of the logistics and support required by the IAEA and the accompanying U.S. Government personnel. It was difficult to promptly accommodate all requests and changes in plans. These had to be communicated to plant supervisors so that personnel could be diverted from their normal duties to assist in setting up verification equipment and to move containers of material identified for verification to the measuring stations. Escorts were often needed on short notice. It is apparent from these experiences that effective communication and cooperation among the IAEA, U.S. Government, and plant personnel, are essential. The IAEA inspection objectives and the operator's activities to meet those objectives should be clearly established before commencement of activities. This was especially important during the first IAEA inspection.

Another feature found useful during the first visit was to have an updated copy of the DIQ available as a reference for information and consultation. Draft copies were provided for on-site use only. These proved to be useful in explaining the Exxon Nuclear safeguards structure, measurement system and controls, and plant layout. The drafts were also helpful during the discussions of the Facility Attachment. For these reasons, we recommend that facilities coming under full IAEA safeguards in the future have available at least a draft version of the DIQ during the first IAEA visit.

Also during this first visit, IAEA, NRC, and Exxon Nuclear personnel discussed the Facility Attachment. Although the Facility Attachment officially is negotiated between the IAEA and the U.S. Government, we believe that operator input during the discussion stage is essential in achieving effective safeguards and allowing us to do so was appreciated.

INTERIM ACTIVITIES

On April 1, 1981, we began reporting inventory changes (receipts and shipments) and inventory status on the revised DOE/NRC Forms 741 and 742, and the new Forms 740M (Concise Note) and 742C (Physical Inventory Listing, or PIL). To date, we have found that the new Form 741 requirements for reporting both transfers between material types (blending) and certain measured discards can be accomplished with little impact on the normal workload. However, because our Facility Attachment is not complete, we have yet to begin reporting batch data on our 741 or 742C reports.

The reporting requirements for the Form 742 have also changed. While these new requirements are not difficult to implement, added vigilance is necessary to maintain and prepare the information in the proper format. The major changes include the need to submit separate 742's for all material types, including natural and depleted uranium, and to submit a separate 742 for four levels of enriched uranium. Additionally, the ending inventory information for each 742 must be broken down by country control number.

Another major change is the need to submit on the Form 742C a detailed breakdown of the physical inventory by batches and other categories. This information replaces and augments what used to be reported on the reverse side of the old Form 742. The 742 and 742C forms were submitted for our March 1981 physical inventory without much extra effort, since reporting of the detailed inventory data on Form 742C (PIL) was not yet required.

We are currently developing an approach for using our computer-based system to summarize the data for the PIL in the desired format. The Form 740M, which is used to clarify and provide additional information for any of the aforementioned reports, or to provide information required by the Facility Attachment, has not been used as yet.

Although use of the new material reporting forms has not yet proven burdensome, the development of a practical and efficient system for providing advance notification (imports, exports, and cylinder heel shipments) has turned out to be a more difficult task for us. This is because we have extensive product and recycle flows between our U.S. fuels fabrication plant in Richland, Washington, and our fuel assembly plant in Lingen, West Germany. We also routinely ship cylinder heels to the U.S. enrichment plants which we understand are "non-eligible destinations". We understand that the requirement to provide advance notification on heel returns to U.S. enrichment plants may be changed or eliminated.

We have not yet established a routine system of advance notification. We have developed from our master production schedule an anticipated operating program for the next two years. We have also developed a tentative plan for providing notification of exports through our internal shipping schedule notification.

MAY 1981 IAEA VISIT

The second IAEA safeguards inspection was conducted from May 18-20, 1981 by three Agency inspectors. Representatives from the NRC were also present. The inspection consisted of flow verification of UF_6 cylinders and at fuel rod loading, auditing our final March 1981 physical inventory records, and again discussing the Facility Attachment. The experience gained during the first IAEA inspection better enabled us to plan and coordinate this inspection.

During this visit, the inspectors observed the reweighing of six full UF_6 cylinders, verified the enrichment of these cylinders and one cylinder heel with their NDA equipment, and checked the cylinder wall thicknesses with their ultrasonic meter. They also verified the weights of three fuel rods, and obtained pellet samples.

The physical inventory records audit consisted of reviewing the plant receipt and shipment records for April 1981, and recording the book balance as of the end of April 1981. Some entries in the accounting system records were verified with the source document (741 form) and with a DOE listing of 741's.

The Facility Attachment discussions centered on a draft version which had been approved by the IAEA Technical Review Group. While not formally approved as yet, there is every indication that the document will provide a reasonable basis for cost-effective safeguards.

ADDITIONAL ACTIVITIES

As an Exxon Nuclear internal check, the weight verification data from the March inspection were evaluated. For each stratum, we generated the difference statistic(4) $\hat{D}_k$, treating the operator-inspector weight differences as the equivalent quantity of uranium element. These values were summed to yield $\hat{D}$ for all verified strata. This total, which we compared to the propagated measurement uncertainty, was not statistically significant, i.e., the hypothesis: $\hat{D} = 0$ was not rejected. It is of interest that the operator-inspector weight differences were similar to those resulting from the routine audits performed by our Internal Controller.

The samples which had been taken during the first two inspections were stored temporarily at our facility under IAEA seals until the export license was received. The samples were then shipped to the IAEA laboratory in Vienna.

SUMMARY AND CONCLUSIONS

Our initial experience under IAEA safeguards for a low-enriched fuel fabrication plant has been presented. To date, we have completed an updated DIQ; modified and augmented our material reporting procedures to meet IAEA safeguards requirements; hosted two IAEA inspections to verify material quantities and to audit records; prepared for and provided a wide variety of support and logistical services; and endeavored to develop innovative, cost-effective approaches for implementing IAEA safeguards. We also participated in informal discussions of the Facility Attachment.

From our initial experience, it is apparent that effective communications and the active cooperation of all parties are essential if the goals of the IAEA and U.S. Government are to be met. While the Facility Attachment is not yet formally approved, there is every indication that it will provide a reasonable basis for cost-effective safeguards. Finally, having learned from these initial experiences, we believe that future IAEA safeguards activities should be much easier for us to manage.

REFERENCES

1. Code of Federal Regulations, Title 10, Part 75, Safeguards on Nuclear Material - Implementation of US/IAEA Agreement.

2. R. Nilson, Panel Discussion on Interaction of International Safeguards, State Systems and Facility Operations, Proceedings of Third Annual Symposium on Safeguards and Nuclear Materials Managment, pages 265-267, May 1981, ESARDA 13, European Safeguards Research and Development Association.

3. Text, Agreement with the International Atomic Energy Agency for the Application of Safeguards in the United States of America, with Protocol, 1978.

4. IAEA Safeguards Technical Manual, Part F, Volume 3.

INITIAL EXPERIENCE UNDER IAEA SAFEGUARDS

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INITIAL EXPERIENCE UNDER IAEA SAFEGUARDS

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INTRODUCTION

The United States, as a party to the Non-Proliferation Treaty (NPT), has joined with other nations in an effort to limit the spread of nuclear weapons. To encourage widespread adherence to the NPT by non-nuclear-weapon states, President Johnson in 1967 announced that the United States would permit the International Atomic Energy Agency (IAEA) to apply its safeguards to nuclear activities in this country. This policy was reaffirmed by each succeeding president.

The formal agreement between the United States and the International Atomic Energy Agency to apply IAEA safeguards in the United States was ratified by the U.S. Senate on July 2, 1980. The Nuclear Regulatory Commission (NRC) published its final rule (10 CFR 75) on July 31, 1980, providing the means by which the Agreement is to be implemented by its licensees. Finally, on December 9, 1980, the US/IAEA Agreement was entered into force. On February 17, 1981, the NRC notified Exxon Nuclear that we had been chosen by the IAEA as the first U.S. fuel fabrication facility to come under the full safeguards agreement.

We expect to be under IAEA safeguards for approximately two years, at which time the Agency is expected to select other facilities for inspection. With now nearly a year under IAEA safeguards, we can report on our experience related to impact and cost. A measure of effectiveness, both from our standpoint and to a certain extent with respect to the technical international safeguards objectives, is also available.

OBJECTIVES OF U.S. SAFEGUARDS OFFER

An important objective of the Presidential offer to apply safeguards in the U.S. was to encourage universal acceptance of IAEA safeguards in non-nuclear-weapon states. In making the offer during the NPT negotiations, President Johnson said "... we in the United States are not asking any country to accept safeguards that we are not willing to accept ourselves". This offer became very important in overcoming complaints of discrimination by prospective parties to the NPT in having to subject their civil nuclear programs to international controls not being imposed on the nuclear weapons states. For example, Japan, West Germany and Italy all ratified the NPT and stated in their ratification statements the key importance of the U.S. offer. Efforts to persuade non-parties to the NPT to accept international safeguards have also been aided by the U.S. offer (as well as similar offers of the UK and France).

Another objective of the offer was to demonstrate U.S. conviction that IAEA safeguards are not burdensome, do not interfere with economic, efficient and safe operation of nuclear facilities, do not compromise commercially valuable proprietary information, and do not hamper the economic or technological development of nuclear energy or the international competitiveness of nuclear supplier nations.

A further objective was to influence the standards in implementing IAEA safeguards. A corollary to this is, that so long as the U.S. was an uninspected nation, it lacked both a working basis to judge the technical effectiveness of IAEA safeguards elsewhere and a practical opportunity to assist the Agency in the development of practical and effective safeguards techniques.

Of course, an important objective of the U.S. nuclear industry is its assurance that the actual burden of implementing IAEA safeguards be justified by the results obtained. In other words, the implementation should be cost effective.

EXPERIENCE

Our experience of nearly one year is based on the preparatory activities to implement IAEA safeguards in our fuel fabrication facility as well as three visits by Agency inspectors. A fourth inspection is taking place this week.

1. Initial Activities

The first step in meeting the requirements of IAEA safeguards was to update the Design Information Questionnaire (DIQ), which we had originally prepared in 1977 as part of a voluntary U.S. program on IAEA safeguards implementation. An example Facility Attachment had also been prepared under the voluntary program.

The preparation of the 1981 DIQ was aided by having the earlier draft. Although both our facility and the DIQ questions had changed since 1977, much of the original text could be retained and limited information from our Fundamental Nuclear Material Control (FNMC) document could also be incorporated directly into the DIQ. (The FNMC document is a plant and safeguards system description which is required by NRC for its safeguards licensing purposes.)

Instructions for preparing the DIQ indicate that pre-printed forms are to be used. However, it was simpler (and permitted by the IAEA) to prepare our DIQ in our own format as a controlled Company document. A section of the text could be devoted to each DIQ question and any necessary tables and figures could be included in that section. In addition, copy distribution and revisions could be handled by our document control system.

It would have been very difficult to prepare a quality DIQ and obtain the necessary internal reviews and approvals in the 45 days allowed by the agreement without having participated in the 1977 voluntary program. In total, the preparation of the DIQ required approximately a man-year of effort with the updating portion taking about two months of continuous effort by one technical individual.

Our book inventory as of February 28, 1981 was submitted to the NRC. This was accomplished by updating our last (September 1980) physical inventory for the material shipped and received, so as to reflect the book balance as of the report date.

The final activities during the initial period were preparing for the first visit of the Agency inspectors. Prior to the visit, we had discussed with IAEA and NRC by phone various approaches for verifying our inventories, overseen customs requirements and transportation of IAEA's measurement equipment to our plant, described in detail our physical inventory taking procedures, and summarized our inventory by strata to assist the inspectors' planning for sampling and verification.

2. First IAEA Visit - March 1981

The first IAEA visit which took place from March 25 to April 1, 1981 was during one of our semi-annual inventories. The purpose of this initial visit was to acquaint the inspectors with our personnel and facilities, to witness the inventory taking, to verify our inventory quantities and to discuss the draft Facility Attachment. (This was an ad hoc inspection, prior to any agreed-upon formal plan or Facility Attachment.) There were five inspectors with six additional personnel from the U.S. Government and one consultant from Battelle-Northwest in attendance.

The inspectors presented their verification objectives from which a plan was derived jointly by them and ourselves. The plan's objective was to sample the plant's inventory and make independent measurements sufficient to detect an inventory discrepancy of 75 kilograms U-235. The inspection in the U.S. is only on three isolated plants. Consequently, it is not possible to verify interplant material flows, and an assurance statement of "no loss" in the U.S. cannot be made. Nevertheless, the techniques developed on only a part of the system are useful in themselves.

The inspectors spent considerable time witnessing our physical inventory taking and reconciliation efforts. They checked our total item count in selected storage areas and applied random sampling plans to select items from main inventory strata for verification of uranium element and enrichment.

The contents of four UF_6 cylinders were verified by observing our reweighing of the cylinders, measuring enrichment with a GeLi detector, and measuring the cylinder wall thicknesses with an ultrasonic meter. The GeLi detector was calibrated for relative response using three UO_2 powder samples of varying (but known) enrichments prepared specially for that purpose. To convert the relative NDA measurements to absolute values, a sample of one of the cylinder's contents (for later IAEA mass spectrometer analysis) was taken while the cylinder's contents were being fed to the UF_6 conversion process.

Forty-five fuel rods, out of a population of 14,000, were ramdomly selected and verified for enrichment using the IAEA's SAM-2 gamma ray counter and our fuel rod scanner. Two full-length reject fuel rods, chosen to match the rod types in the IAEA's sample, were used as standards for the scanner. To convert the relative values to absolute values, the two standard rods were down loaded for weight verification and sampling of pellets for later destructive analysis at IAEA Headquarters.

Thirty-eight powder and eight scrap buckets were verified for mass. uranium content and enrichment by observing our reweighing, measuring each bucket on our SAM-2 for enrichment. and taking samples from ten of the buckets for later destructive analysis in Vienna.

Pellets were also verified for mass, uranium content and enrichment by observing our reweighing and taking samples for later analysis. In this stratum, 75 pellet trays and one pellet boat were reweighed and eight pellet samples were taken.

Three solid waste barrels were also selected and remeasured using our waste assay counter. Two standard waste barrels were also measured.

During the visit, the Facility Attachment was discussed. The Facility Attachment is the official agreement between the IAEA and the U.S., which describes, for the particular facility, reporting and notification requirements, sharing of costs, key measurement points, number of MBA's for reporting purposes, containment/surveillance arrangements, accounting and operating records, measurement controls, man-days per year and scope of inspection, and content of inspection results. Although the Facility Attachment is officially negotiated between the IAEA and the U.S. Government (NRC), we were permitted to participate in the negotiations which later proved helpful in achieving a workable and cost-effective plan.

3. Interim Activities

In the past, U.S. licensees were required to make two types of routine safeguards reports. Form 741 was a material transaction report analagous to the IAEA's inventory change report and was used to report to the NRC all nuclear material transfers into or out of the licensee's facility. Form 742 was a material status report and was used to report to NRC the licensee's inventory of nuclear material following an inventory taking. To accommodate the IAEA reporting requirements, the NRC and DOE have modified the 741 and 742 forms so that duplicate reporting is not required for those facilities under IAEA safeguards. However, some additional complexity has resulted. The new 741 forms require identifying batches and treating certain measured discards and enrichment changes resulting from blending as inventory changes. Also, the ending inventory information on each 742 must be broken down by country control number and natural and depleted uranium have been added as reportable material types.

Two new reports, Form 740M for concise notes (to be attached to the other forms as required) and Form 742C to provide a detailed listing of inventory (by batch) have been added. Form 742C provides the inspectors a detailed physical inventory listing (PIL) to facilitate their evaluation of the inventory verification data.

We began reporting material transactions on the new 741 form on April 1, 1981. We also reported our material balance status following the March physical inventory on the new 742 forms. We have not yet included batch reporting on 741 forms, nor have we submitted any 742C forms. However, we have reprogrammed our computer material accounting system to provide output for the PIL directly into the 742C batch format.

In addition to the above reporting requirements, the IAEA requires advance notification of exports and imports. We send this information to the NRC Regional Office for their transmittal to the IAEA.

We have yet to submit a new Form 740M which is to be used to clarify and provide additional information for any of the aforementioned reports or to provide special information required by the Facility Attachment.

4. Second IAEA Visit - May 1981

The second IAEA safeguards inspection was conducted from May 18-20, 1981 by three Agency inspectors. Two representatives from the NRC were present. The experience gained during the first IAEA inspection enabled us to better plan and coordinate this inspection. The purpose of this inspection was to perform flow verification of UF_6 receipts and pellet loadout and to audit accounting records.

The inspectors observed the reweighing of six UF_6 cylinders and verified enrichment with their instruments. They also checked the heel of one empty cylinder and verified our weights for three fuel rods. Six samples of pellets were taken for NDA at Vienna.

The accounting records were audited by reviewing the plant receipt and shipment records for April 1981 and recording the book balance as of the end of April 1981. Some entries in the accounting system records were verified against the source documents (741 forms).

The draft Facility Attachment was again discussed. The draft version had at that time been approved by the IAEA Technical Review Group.

5. Third IAEA Visit - August 1981

The third IAEA visit was from August 12-14, 1981 with four inspectors and one NRC Staff member present. The purpose of this visit was to test the quality of some of our measurements and records. The inspectors again verified enrichment and gross weights of UF_6 cylinders, weighed and sampled UO_2 powder buckets and audited records. The Facility Attachment was again reviewed to assure that all changes agreed to during the May discussions had been incorporated into the "draft" final version.

The next IAEA inspection is this week, December 2-4, 1981. The purpose of this inspection is to conduct another records audit, verify the contents of UF_6 cylinders, and to plan for the IAEA verification of our next physical inventory (March-April, 1982).

RESULTS

Several innovative approaches have been jointly developed during the inspections to improve cost-effectiveness of the verification process. For example, it was possible to reduce the originally desired forty-six samples for UO_2 powder and scrap to ten by substituting an enrichment meter (SAM-2) attribute test for each powder and scrap bucket to detect gross defects. This approach saved time and effort, since verification with a SAM-2 is many times faster than sampling and later destructive analysis, and does not require the constant presence of material handlers.

The first approach considered for fuel rod verification was to scan selected rods with a SAM-2, and then for our operators to prepare from excess material several short "rodlets" for SAM-2 standards and to obtain pellet samples for destructive sampling. Such rodlets were to be prepared for each different enrichment and for each unique cladding and pellet size. Because of the many different pellet-cladding sizes and enrichments and the logistics in collecting the needed materials and preparing the rodlets, this approach was determined to be impractical. As an alternative, it was agreed that reject fuel rods could be used for standards and downloading these rods could also provide the pellet samples for destructive analysis. This suggestion and the use of our rod scanner on a non-priority basis were then adopted as the final concept, an approach which was more accurate, faster, and much less costly than originally planned.

For percent uranium and enrichment, we have been told informally by the IAEA that their analytical results on pellet samples taken in March were in good agreement with ours. As an internal check, we have evaluated the weight verification data from the March inspection and found that the operator-inspector weight differences were similar to those we find in our routine audits.

Our input to the Facility Attachment was also utilized and resulted in simplifications. For example, we advocated a single reporting MBA which eliminates unnecessary material transaction reporting between receiving and process and process and shipping.

The new reporting requirements have been accomplished so far with minor impact. While the changes in reporting have not been difficult to make, care is required to prepare and keep the information in the proper format.

No lost production time has resulted, since the IAEA's inventory verification has been accommodated during the normal shutdown period for inventory taking. The total impact to date in direct costs is about 15¢ per kilogram of fuel produced.

SUMMARY AND CONCLUSIONS

Our initial experience under IAEA safeguards for a low-enriched fuel fabrication plant has been quite satisfactory. To date, we have completed a DIQ, modified and augmented our material reporting procedures to meet NRC and IAEA requirements, hosted three IAEA inspections for a total of 47 man-days, prepared for and provided support and logistical services and cooperated with the inspectors to develop cost-effective approaches for implementing the IAEA safeguards in our facility.

The above has been accomplished within a cost and schedule impact which to date has not been overly burdensome. Equally important, the inspection effort has achieved its goal of detecting an inventory discrepancy of 75 kg U-235 with a reasonable level of measurement and sampling. Based on our experience, the objectives of the industry are being met on all counts.

Admittedly, one fuel plant and two nuclear power reactors under international safeguards do not constitute a large data base for conclusions regarding IAEA safeguards for the United States. However, the meeting of the industry's objectives of the U.S. offer and as well the goals of the Agency, is of considerable significance even at this implementation level. A large part of this fulfillment is attributable to the close interaction now available between the inspectors and the U.S. private nuclear industry operators. Whether this experience is useful elsewhere remains to be seen, but in my opinion, the experience cannot help but benefit civil nuclear programs of other nations, particularly if the acceptance of IAEA inspection is made more palatable by its virtue of being cost effective, a goal shared by all.

IMPLEMENTATION OF INTERNATIONAL SAFEGUARDS
- AN OPERATOR'S VIEWPOINT

By

R. A. Schneider and E. R. Herz

Exxon Nuclear Company, Inc.
Richland, Washington

Prepared for presentation at the invited paper session entitled, "International Safeguards Implementation", of the Fifth International Conference on "Nondestructive Evaluation in the Nuclear Industry" to be held in San Diego, California on May 10-13, 1982.

IMPLEMENTATION OF INTERNATIONAL SAFEGUARDS

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INTRODUCTION

The United States, as a party to the Non-Proliferation Treaty (NPT), has joined with other nations in an effort to limit the spread of nuclear weapons. To encourage widespread adherence to the NPT by non-nuclear-weapons states, President Johnson in 1967 announced that the United States would permit the International Atomic Energy Agency (IAEA) to apply its safeguards to nuclear activities in this country. This policy was reaffirmed by each succeeding president.

The formal agreement between the United States and the International Atomic Energy Agency to apply IAEA safeguards in the United States was ratified by the U.S. Senate on July 2, 1980. The Nuclear Regulatory Commission (NRC) published its final rule (10 CFR 75)(1) on July 31, 1980, providing the means by which the Agreement is to be implemented by its licensees. Finally, on December 9, 1980, the US/IAEA Agreement was entered into force. On February 17, 1981, the NRC notified Exxon Nuclear that its Richland, Washington plant had been chosen by the IAEA as the first U.S. fuel fabrication facility to come under the full safeguards agreement.

The paper is presented in the following order. First, the various operator and inspector activities which have been carried out at our low enriched uranium fuel fabrication plant for the implementation of international safeguards are presented. Next, the methods which are used by us to measure nuclear materials and the measurements used by the inspector to verify our statements of nuclear material content are described. This is followed by a discussion of the requirements and approaches for the verification of material quantities including the verification of both individual items and total quantities in a population of items. Various cost elements resulting from the implementation of IAEA safeguards are then discussed as well as some assessment of effectiveness. The summary and conclusions are given at the end of the paper.

REQUIREMENTS AND ACTIVITIES

General

Since being selected in February 1981, we have carried out a number of activities to meet IAEA requirements. These have included:

1. Preparation of a Design Information Questionnaire (DIQ);
2. Development and implementation of new material reporting formats for our computer-based accounting system;
3. Hosting a number of IAEA inspections to verify material quantities and to audit records;
4. Providing advance notification on exports and imports; and
5. Providing a variety of support and logistical services.

Those activities of more general interest are described in more detail below.

Design Information Questionnaire

The DIQ is a formal document of about 100-150 pages which describes in some detail the plant's location, layout, process and measurement and accounting systems. The DIQ is prepared upon notification from the U.S. -NRC that the plant has been selected for IAEA safeguards. It must be written and submitted to NRC within 45 days of notification of selection.

Inspection Activities

To date, we have had six on-site inspections by the IAEA or about one inspection every two months. The two inspections which were inventory verifications involved about six IAEA inspectors and were carried out over a four to six day period. The other four inspections were conducted for periods of two to three days by two to three inspectors. Typical inspector activities included making nondestructive assay (NDA) measurements on UF_6 cylinders; observing operator measurements; calculating the number of samples for random sampling plans and selecting samples; sealing samples; and auditing operator records and reports. Corresponding activities by us included weighing and moving UF_6 cylinders; assisting the inspectors in setting up and moving their NDA equipment; weighing materials and operating our SAM-2 enrichment meter (Stabalized Assay Meter) and rod scanner under IAEA witness; locating items selected by the IAEA for verification and moving those items to the verification station; and preparing accounting data and reports.

General Logistics

General logistics support for accommodating IAEA inspections have included providing customhouse brokerage and freight forwarding services for bringing IAEA NDA equipment into the country and for exporting inspection samples to Vienna, Austria. Other support has consisted of supplying dosimeters, escorts, office space, working standards, liquid nitrogen, shop space for calibrating and setting up [illegible] equipment, electrical hookups and conducting a special rod scanner experiment.

MEASUREMENTS

Operator Measurements

The measurements used by us for accountability purposes are shown in Table 1. The measurements are called accountability measurements since their results are the ones which are booked into the accounting records. For the most part, the amounts of uranium element and U-235 in an item are based on a weight or volume measurement, sampling, and destructive analyses of the sample for uranium element and U-235. For uranium powders and pellets, we use the gravimetric method. For liquid waste samples, the fluorimetric uranium is used. Nearly all accountability values for U-235 are based on analysis by mass spectrometer. Our accountability measurement for solid waste is based on passive gamma counting of waste barrels and HEPA filters. In addition, three NDA (nondestructive assay) measurements which are used primarily for quality control are also used as safeguards overchecks. Each fuel rod is assayed with either our active rod scanner, or in case the rod contains a nuclear absorber, a passive scanner. The SAM-2 enrichment meter is also used extensively throughout the process as an enrichment control overcheck.

Verification Measurements

The verification measurements used by the IAEA for the various items comprising the nuclear material inventory are shown in Table 2.

TABLE 1

PLANT ACCOUNTABILITY MEASUREMENTS

Item	Measurement Method
UF_6 in cylinders	Weighing, sampling, U and U-235 assay
Pellets in Boats and Trays	Weighing, sampling, U and U-235 assay
Uranium Powder in Buckets	Weighing, sampling, U and U-235 assay
Solid Wastes in Barrels and Filters	Passive gamma, waste assay counter
Liquid Waste in Large Basins	Volume, sampling, U and U-235 assay
Fuel Rods	Pellet column weight, sampling, U and U-235 Assay
Fuel Bundles	Summation of rod values

TABLE 2

MAIN IAEA VERIFICATION MEASUREMENTS

Item	Verification Measurements
UF_6 in Cylinders	Weighing, enrichment by NDA or by U-235 analysis of special sample, U by assay of special sample
Pellets in Boats and Trays	Weighing, sampling, and U and U-235 analyses of pellets
Uranium Oxide Powders in Buckets	SAM-2 attribute test, weighing, and sampling, U and U-235 assay of powder sample
Fuel Rods	Use of operator rod scanner with standards by destructive analysis
Fuel Assemblies	Neutron collar experiments planned.

The enrichment of our plant's starting material (UF_6 in cylinders) is verified with a Ge(Li) detector by measuring the U-235 gamma rays coming through the side of the cylinder. An ultrasonic thickness gauge is used to measure the thickness of the steel UF_6 cylinder wall to correct for gamma ray attenuation. Enrichment verification can also be carried out for UF_6 cylinders being processed by sampling the process vessel where UF_6 gas reacts with water. By contrast, to verify the uranium element composition of UF_6 at our plant, a special sample must be taken from the UF_6 vapor line when a cylinder is being processed.

The inspector verifies fuel pellets in sintering boats and pellet trays for weight by having us reweigh them under their witness Samples of the pellets are selected for measurement of U and U-235 at the IAEA laboratory. Our statements of the nuclear material content of uranium oxide powders in buckets (e.g., in 5 gallon pails) are also verified by weighing and obtaining a sample for U and U-235 analysis at the IAEA laboratory.

The inspectors also use an attribute (gross defect) test using our SAM-2 enrichment meter. The buckets selected for verification are first reweighed, then machine tumbled to mix any extraneous material, and finally measured for enrichment on the operator's enrichment meter. After the enrichment measurements are completed, a fraction of the buckets are opened, inspected and sampled for U and U-235 analyses at the IAEA laboratory. The buckets which are sampled and measured by destructive IAEA analysis serve as "independent" standards for our SAM-2 enrichment meter.

A similar approach has been tested for verifying the content of fuel rods. Fuel rods selected for verification by the IAEA are measured using our active rod scanner for total fissile counts and for enrichment uniformity. The rods are measured against full length "standard" rods selected from the reject or excess rod inventory which match the rods under test. At the end of the verification with the rod scanner, one or more of the "standard" rods are downloaded by opening one end and sliding the pellets onto a weighing tray for weight verification and selection of pellet samples by the IAEA. This approach, which is equivalent to the destructive analysis of the standard rods, provides the IAEA with "independent" standards which match the rods being verified.

Two new instruments are being tested to provide the inspectors with a greater degree of independence. One is a load cell weighing device which fits on our crane attachment.(2) This device allows the inspector to make, in effect, an independent weight measurement of UF_6 cylinders. The second device is a neutron collar(3) attachment for nondestructively assaying fuel assemblies.

Verification Approach

For the verification of our statements of the quantities of nuclear materials contained in a population of inventory items, the inspectors use an attribute-variable plan(4). This type of random sampling plan is designed to detect with high probability the absence (or overstatement) of a quantity of nuclear material of safeguards importance (a goal quantity). The plans are designed to be effective regardless of whether the removal of a goal quantity is achieved by taking a small number of whole items or by partially removing material from many items, or by removing a small amount of material from a number of items (or any mixture removals). Three sample sizes are generally computed. The largest sample size is used to select items for measurement by an attribute test (a single pass or fail measurement) to detect large differences. A second smaller sample (the true variables sample) size is used to select items for measurement by a more exact variables measurement method to detect small differences and/or biases. Usually, the variables method is used to find the average difference for a number of items or the average difference of repeated measurements on one or several items. A third sample size is used to select items for measurement using the variables method in the attribute mode to detect medium sized differences which are too small to be detected by the attribute method.

The magnitude of the third sample size, which is often the controlling sample size for variables measurements, is determined by the power of the attribute method to detect with nearly 100 percent certainty a medium sized difference. The smaller the difference which can be detected by the attribute instrument, the smaller the sample size required for using the variable method in the attribute mode.

An example of the value of a nondestructive instrument for use as an attribute test for detecting medium to large defects is shown in Table 3. The first row in Table 3 shows the case where there is no NDA attribute instrument available and the accurate but expensive variables method must be used to detect gross defects. In the example, that sample size is 78 items. The second row shows the significant reduction in the sample size by using an NDA instrument for the attribute test, a reduction from 78 to 32 samples for that test. Row three of Table 3 shows the further decrease in the sample size which can be achieved if the attribute instrument's power of detection increases from detecting 40 percent (of the material in an item) missing to 20 percent missing. Row four shows the further decrease in sample size if the power of detection increases to the detection of the absence of 10 percent of the material from an item. The true variables sample size which is not shown in the table is four in all cases

Another important part of the verification process is to verify that all of the inventory items stated by the operator are actually present. The total number of items may be verified by a random sampling plan if the

TABLE 3

EXAMPLE OF REDUCTION OF SAMPLE SIZE WITH AVAILABILITY OF NDA INSTRUMENT

Case	Attribute Sample Size	Attribute Mode-Variable Sample Size
No instrument available	78	78
40%[(1)]	78	32
20%[(1)]	78	16
10%[(1)]	78	8

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(1) The percentage of material which if missing from an item can be detected by the NDA instrument with nearly 100% certainty by a single measurement.

inspector is provided with a list of the individual inventory items. In this case, items can be selected randomly from the list and the inspector can verify that those items are actually present. This process of selecting items from a list and then locating the item in the plant can be greatly facilitated if the operator numbers each inventory item and inventory storage bin with sequentially-numbered inventory stickers.

It is also necessary that the inspector have assurance that the operator's final listing of total inventory quantities and item values is the same as the values stated at the time of verification. Since the operator knows which items the inspector has verified, he could, for example, alter the values of the items not verified by the inspector when he prepares his final listing. The inspector could, of course, record the tag value of each inventory item during his verification. However, this is a costly and time-consuming task, desired neither by the operator nor the inspector. A practical solution is to provide the inspector with an initial list of the inventory (prior to verification) which includes the nuclear material content of each item. The inspector can then make a one-to-one comparison between the two lists to assure that the final inventory listing is correct and that the item values sum to the correct totals.

ELEMENTS OF COST-EFFECTIVENESS

Costs

The main costs that we have found to-date which arise from the IAEA's verification of material quantities include the manpower expended in escorting inspectors, performing verification measurements, locating items for verification measurements, preparing accounting reports and inventory lists, and providing incidental services.

Perhaps the most important cost concern to the operator is the potential for lost production from having to "freeze" the inventory until the IAEA can do its verification activities or having to slow or halt production in certain areas so that IAEA verification measurements can be made.

Effectiveness

The effectiveness of the verification of operator statements of item contents is dependent on the quality and number of both the inspector and operator measurements. It is also dependent on the extent to which inspector's verification measurements can be deceived by material substitution schemes or adversary strategies. The effectiveness with which a population of items may be verified (using a random sampling plan) is dependent on the number of items verified for content and item identification and the extent to which the requirements for randomness are met, e.g., the operator stated his value for each item before the inspector applies his random sampling plan.

There are several positive actions which the operator can take to minimize his verification cost burden. These include improving (or maximizing) the "verifiability" of his inventory so as to facilitate the IAEA's verification of the inventory. Such actions include 1) designing the physical count sheets for inventory taking so that they may also serve as the "itemized" statement of the operator's inventory required by the IAEA before it can verify an inventory strata and 2) numbering each inventory item or inventory storage bin with a sequentially-numbered sticker to facilitate the selection and location of items for verification. The operator can also endeavor to schedule his inventory near a normal production break (e.g., a weekend) so that inventory verification can be carried out during the normal production break. This arrangement calls for the close cooperation of the operator and the inspector. The most efficient arrangement is to have the operator teams first complete the physical inventory of the area and then provide the inspection team with copies of the physical count sheets (the itemized inventory list) so that the inspector's verification can immediately follow the physical inventory taking. By this approach, verification activities can often be completed within the working shift following the operator's inventory taking and production can be resumed with a minimum of lost time. We have done all of the above with the cooperation of the inspectors.

It is estimated that use of our active rod scanner saved approximately four man days of inspector-operator time compared to a "manual" scan of fuel rods with a passive gamma counter. The rod scanner approach (assuming independence is achieved by the standardization approach noted earlier) is also more exact approaching, in principle, the quality of the weight-assay method.

The use of the SAM-2 enrichment meter as an attribute test for low enriched uranium oxides in buckets reduced the variables sample size by a factor of about three from what it would have been if the variables method (weighing, sampling, and analysis) had been used instead for the attribute test.

Most of the inventory items at a low enriched uranium fuel fabrication plant can now be verified by independent measurement to a good degree of exactness. The operator-inspector measurements for bulk materials (powder and pellets) based on weighing, sampling, destructive assay for uranium and U-235 by mass spectrometer can approach the best state of measurement art. The enrichment of UF_6 in cylinders can now also be measured with a good degree of exactness and serves as an excellent attribute test. The active rod scanner provides a verification capability for fuel rods which approaches the high quality of weight-assay measurements for total U-235 in fuel rods.

The actual burden of IAEA safeguards inspection has not been large. We previously estimated(5) that our cost is about 15 cents a kilogram of uranium fuel produced.

SUMMARY AND CONCLUSIONS

Our experience gained to date from implementation of IAEA verification at our fuel fabrication plant has been described. From that experience, we have concluded that the IAEA verification of material quantities is generally technically effective and is not overly burdensome. We also believe that the operator can, to some extent, minimize his costs for the verification of his inventory by the IAEA by maximizing the "verifiability" of the inventory. The cooperative efforts of the inspector and operator in planning, scheduling, and coordinating the combined activities of inventory taking by the operator and inventory verification by the IAEA, are able to significantly reduce the potential for lost production. Lastly, it has been shown that non-destructive assay instruments play an important role in the efficiency and effectiveness of IAEA verification.

REFERENCES

1. Code of Federal Regulations, Title 10, Part 75, Safeguards on Nuclear Material - Implementation of US/IAEA Agreement.

2. A. M. Fainberg, Brookhaven National Laboratory, "Description of Load Cell Weighing Device", Private communication, February 1982.

3. H. O. Menlove, "Description and Performance Characteristics for the Neutron Coincidence Collar for the Verification of Reactor Fuel Assemblies", Los Alamos National Laboratory, LA-8939-MS (1981).

4. IAEA Safeguards Technical Manual, Part F, Volume 3.

5. R. Nilson, "Initial Experience Under IAEA Safeguards", paper presented at the 1981 Winter Meeting of the American Nuclear Society, San Francisco, California, November 29-December 4, 1981.

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August 16, 1982

Mr. L. Manning Muntzing
President, American Nuclear Society
Doub and Muntzing
1875 Eye Street, N.W.
Washington, D.C. 20006

Dear Mr. Muntzing:

We appreciated having you testify on the subject of safeguards research and development programs at the Subcommittee's hearing on August 4, 1982. Chairman Bouquard would like to supplement the record of the hearing with some additional questions regarding the programs. We appreciate your cooperation on this matter and we hope that this information can be provided by September 7, 1982.

If you have any general questions regarding these requests, please contact me at 202/225-8056. If you have any questions regarding the specifics, please contact Dr. Harlan Watson of the Subcommittee staff at 202/225-3472.

Sincerely,

John V Dugan Jr/jms
JOHN V. DUGAN, JR., Staff Director
Subcommittee on Energy Research
and Production

JVD:Wjs
Enclosures

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
CHAIRMAN BOUQUARD'S QUESTIONS ON
TECHNICAL ASPECTS OF NUCLEAR NONPROLIFERATION: SAFEGUARDS
Hearing held August 4, 1982

1. Mr. Muntzing, you stated that you would not favor amending the Nuclear Nonproliferation Act of 1978 at this time. However, you also stated that you had a list of items that you would change if you were rewriting the Act. What changes would be included in your list?

2. If you had it within your power and authority to devise a different scheme or organizational format for conducting international and domestic safeguards research and development, how would you change the current set-up?

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PRESIDENT
L. Manning Muntzing
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1875 Eye Street, NW - Suite 775
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September 14, 1982

Mr. John V. Dugan, Jr.
Staff Director
Subcommittee on Energy Research
and Production
Committee on Science and Technology
U. S. House of Representatives
Suite 2321
Rayburn House Office Building
Washington, D. C. 20515

Dear Mr. Dugan:

This is in response to your letter of August 16, 1982, asking for my views on the following two questions:

Question No. 1: You stated that you would not favor amending the Nuclear Non-Proliferation Act of 1978 at this time. However, you also stated that you had a list of items that you would change if you were rewriting the Act. What changes would be included in your list?

Answer:

Possible amendments to the Nuclear Non-Proliferation Act should include the following:

1. Eliminate the requirement for annual extension of co-operation with EURATOM.

2. Shift the export licensing responsibility to the Executive Department from the Nuclear Regulatory Commission.

3. Eliminate one House veto provisions and concurrent resolution veto provisions, although this matter is now pending in the Supreme Court.

4. Direct the Executive Branch to provide contract relief to foreign enrichment customers who cannot obtain delivery of their enrichment product due to current or future U. S. laws.

5. Eliminate the requirement for termination of U. S. nuclear cooperation with countries lacking "full-scope" safeguards and substitute a more flexible set of strict requirements for limited U. S. nuclear cooperation with countries presently lacking full-scope safeguards. Those requirements could include:

   a. Limitation on types of nuclear commerce with non-full-scope safeguards countries;

b. Requirement of Presidential certification that satisfactory progress is being made toward achievement of full-scope safeguards.

Question No. 2: If you had it within your power and authority to devise a different scheme or organizational format for conducting international and domestic safeguards research and development, how would you change the current set-up?

Answer:

The current practice of IAEA identifying its needs and relying upon its member countries to accomplish appropriate safeguards research and development is probably the best format for the agency to organize for research and development. It provides considerable flexibility and capitalizes on already existing facilities and expertise. It often provides a number of approaches to the same need, from which an optimum solution specific for the agency's purposes can be chosen.

The only organization related change which may be beneficial relates to the manner of domestic funding for international safeguards research and development. Currently a great deal of the funding flows out of the Armed Services Committee. Considering its principal concern with National Defense, and the difficult funding decisions it must make, it is not easy to generate the interest and needed attention for international safeguards research and development or to justify the needed funding. It seems to me that there are more appropriate committees with more specific safeguards interests within which safeguards research and development funding could be consolidated and better monitored.

However, I believe that what is needed today is not a change in the way research and development is organized, but rather a change in emphasis and thrust of the program. What is needed is more technical support and a greater emphasis on applications engineering to effect the needed technology transfer. Both the inspectors and plant operators need to be integrated with the applications engineering, and well engineered techniques need to be promptly incorporated into an inspector training program which involves practical application under typical field conditions.

Very sincerely,

L. Manning Muntzing

LMM:evm

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NUCLEAR SAFEGUARDS: SELECTED REFERENCES

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Introduction

This bibliography lists selected citations to materials on nuclear safeguards, focusing on those administered by the International Atomic Energy Agency and on related U.S. policy and support for them.

Citations listed in the bibliography were selected from the CRS Bibliographic Data Base, the Library of Congress Computerized Catalog, the Department of Energy's RECON Data Base, and the NTIS Data Base. Library of Congress call numbers have been provided when available. The designation law indicates materials that are held in the Library of Congress Law Library. Publications available from NTIS may be examined on microfiche in the Library of Congress Science Reading Room (LA-5008).

Acronyms used in the bibliography

ERDA	Energy Research and Development Administration
IAEA	International Atomic Energy Agency
INFCE	International Nuclear Fuel Cycle Evaluation
LMFBR	Liquid metal fast breeder reactor
NDA	Non destructive analysis
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
NRC	Nuclear Regulatory Commission

Ayers, A. L., and L. D. Barnes. Development of an advanced safeguards system as a proliferation deterrent. Transactions of the American Nuclear Society, v. 30, 1978: 296-297. QC770.A47, v. 30

Baldonado, O. C., and others. Safeguards systems concepts for nuclear material transportation; final report. [Washington, U.S. Nuclear Regulatory Commission, available from NTIS] 1977. 2 v.
"NUREG-0334" and NUREG-0335"

Bambas, K. J. Potential for meeting IAEA safeguards goals for reprocessing. In International Executive Conference on Nonproliferation and Safeguards, Mexico City, 1980. Barnswell, S.C., Allied-General Nuclear Services [available from NTIS] 1980. 12 p.
"AGNS-35900-CONF-85"

Barkenbus, J. N. International acceptability of advanced safeguarding techniques. Oak Ridge, Tenn., Oak Ridge Associated Universities, Institute for Energy Analysis [available from NTIS] 1979. 60 p.
"ORAU/IEA-79-18(R)"

Bartels, W. C. U.S. technical assistance to IAEA safeguards. In Transactions of the American Nuclear Society, v. 30, 1978: 347-348.
QC770.A47, v. 30

Bennett, C. A., and others. A review of the application of strategic analysis to material accounting; a consensus report. Argonne, Ill., Argonne National Laboratory [available from NTIS] 1979. 70 p.
"NUREG/CR-0950"

Bennett, Carl A., William M. Murphey, and Theodore S. Sherr. Societal risk approach to safeguards design & evaluation. [Washington, U.S. Energy Research and Development Administration] 1975. 58 p.
"ERDA-7"

Blakeman, E. D. Safeguards against proliferation of nuclear materials: a review and bibliography. Oak Ridge, Tenn., Oak Ridge National Laboratory, Nuclear Safety Information Center [available from NTIS] 1980. 153 p.
"NUREG/CR-1146"

Brewer, Thomas L. Nuclear energy forecasts and the international safeguards system. Technological forecasting and social change, v. 11, no. 1, 1977: 9-23.

Cobb, D. D., and others. Development and demonstration of near-real-time accounting systems for reprocessing plants. Los Alamos, N.M., Los Alamos National Laboratory [available from NTIS] 1981. 12 p.
"CONF-810706-29"

Coleman, Jerry Peter. International safeguards against non-government nuclear theft: a study of legal inadequacies. International lawyer, v. 10, summer 1976: 493-513. JX1.I63, v. 10

Conference on Nuclear Safeguards, Orlando, Florida, 1976. Program report. Washington, Atomic Industrial Forum [1976]. 1 v. (various pagings)

Deitrich, J. R. Safeguarding the nuclear fuel cycle. Nuclear engineering international, v. 22, Nov. 1977: 57-61.

Demuh, A. N. Dymac accountability system. Transactions of the American Nuclear Society, v. 34, 1980: 167-168. QC770.A47, v. 34

Dickeman, R. L. Safeguards perspectives: an expression of industry's responsibilities and views. Nuclear materials management, v. 5, summer 1976: 42-46.

Donnelly, Warren H., and Allan M. Labowitz. The International Atomic Energy Agency: application of safeguards in the United States; an analysis of the agreement and an assessment of the negotiation prepared for the Committee on Foreign Relations, United States Senate by the Environment and Natural Resources Policy Division, Library of Congress. Washington, U.S. Govt. Print. Off., 1979. 91 p.
At head of title: 96th Cong., 1st sess. Committee print.

Egen, Gregg M. A study of nuclear safeguards under the International Atomic Energy Agency. [Washington] Atomic Industrial Forum, 1976. 32 p.

Eklund, S. Confidence in nuclear safety and non-proliferation of nuclear weapons: a prerequisite for further development of nuclear power. In Nondestructive evaluation in the nuclear industry: proceedings of an international conference, 13-15 February 1978, Salt Lake City, Utah. Sponsored by the Materials Testing and Quality Control Division of the American Society for Metals ... et al. R. Natesh, editor. Metals Park, Ohio, The Society, 1978. p. 1-13. TA417.2.N66

Fischer, D. A. V. Safeguards under the Non-Proliferation Treaty. Disarmament, v. 3, July 1980: 35-39. JX1974.D48, v. 3

Goldschmidt, Bertrand. A historical survey of nonproliferation policies. International security, v. 2, summer 1977: 69-87. JX1901.I67, v. 2

Green, L., H. Kouts, and W. Marcuse. IAEA costs and manpower requirements under NPT. Upton, N.Y., Brookhaven National Laboratory [available from NTIS] 1970. 34 p.
"BNL 50263 (T-593)"

Green, Leon. Technical assistance to IAEA safeguards. Nuclear materials management, v. 8, proceedings issue, 1979: 382-390.
Paper presented at the 20th annual meeting of the Institute of Nuclear Material Management, Albuquerque, N.M., 1979.

Greenhalgh, Geoffrey. Nuclear safeguards and non-proliferation. In his The necessity for nuclear power. [London] Graham & Trotman [1980] p. 210-220.

Grumm, H. IAEA safeguards--where do we stand today? International Atomic Energy Agency bulletin, v. 21, Aug. 1979: 32-39. QC770.I493, v. 21

Gummett, Philip. From NPT to INFCE: developments in thinking about nuclear non-proliferation. International affairs (London), v. 57, autumn 1981: 549-567.

Hakkila, E. A. Materials management in an internationally safeguarded fuels reprocessing plant, by E. A. Hakkila and others. Los Alamos, N.M., Los Alamos Scientific Laboratory [available from NTIS] 1980. 3 v.
"LA-8042"

----- Role of materials accounting in integrated safeguards systems for reprocessing plants, by E. A. Hakkila and others. Los Alamos, N.M., Los Alamos Scientific Laboratory, 1981. 7 p.
"LA-UR-81-1368"
Paper presented at the Symposium on Safeguards and Nuclear Material Management, Karlsruhe, Federal Republic of Germany, 1981.

Hatcher, C. R. U.S. development of NDA instruments for IAEA. Transactions of the American Nuclear Society, v. 30, 1978: 348-349. QC770.A47, v. 30

Haynal, G. Canadian safeguards policies. In International Symposium on Uranium Supply and Demand, London, 1977. Uranium supply and demand: proceedings of an international symposium held by the Uranium Institute in London, June 22, 1977. London, Mining Journal Books, 1977. p. 81-86.

Higinbotham, W. A. Safeguards technology. In Nuclear energy and nuclear weapon proliferation. Sponsored by Stockholm International Peace Research Institute. London, Taylor & Francis; New York, Distributed in U.S.A. by Crane, Russak, 1979. p. 187-197. TK9006.N75

Houck, Frank S. IAEA safeguards from a United States perspective. Nuclear materials management, v. 8, proceedings issue, 1979: 391-397.
Paper presented at the 20th annual meeting of the Institute of Nuclear Materials Management, Albuquerque, N.M., 1979.

Imai, Ryukichi. Safeguards--a new approach. Nuclear engineering international, v. 24, Apr. 1979: 53-56. TK9001.N75, v. 24

International Atomic Energy Agency. IAEA contribution to INFCE; the present status of IAEA safeguards on nuclear fuel cycle facilities. [Vienna] 1979. 64 p.
"INFCE/SEC/11"

----- IAEA safeguards: an introduction. Vienna, 1981. 38 p.

----- IAEA safeguards glossary. Vienna, 1980. 88 p. TK9009.I57 1980

----- Non-proliferation and international safeguards. Vienna, 1978. 76 p.
"Prepared in connection with United Nations special session of General Assembly devoted to disarmament, 23 May to 28 June 1978."

----- A short history of non-proliferation. Vienna, 1976. 50 p.
JX1974.7.I583 1976

International Nuclear Fuel Cycle Evaluation.

Working Group Reports

----- Assurances of long-term supply of technology, fuel and heavy water and services in the interest of national needs consistent with non-proliferation; report of Working Group 3. Vienna, International Atomic Energy Agency [New York, sold by UNIPUB] 1980. 101 p. TK9360.I64 1980, v. 3
"INFCE/PC/2/3"

----- Enrichment availability; report of Working Group 2. Vienna, International Atomic Energy Agency [New York, sold by UNIPUB] 1980. 155 p. TK9360.I64 1980, v. 2

----- Fast breeders; report of Working Group 5. Vienna, International Atomic Energy Agency [New York, sold by UNIPUB] 1980. 217 p.
TK9360.I64 1980, v. 5

----- The present status of IAEA safeguards in nuclear fuel cycle facilities; report of Working Group 4. Vienna, International Atomic Energy Agency [New York, sold by UNIPUB; available from NTIS] 1978. 57 p.
TK9360.I64 1980, v. 4
"INFCE/DEP/WG-4/115"

----- Reprocessing, plutonium handling, recycle; report of Working Group 4. Vienna, International Atomic Energy Agency [New York, sold by UNIPUB] 1980. 300 p. TK9360.I64 1980, v. 4
"INFCE/PC/2/4"

----- Spent fuel management; report of Working Group 6. Vienna, International Atomic Energy Agency [New York, sold by UNIPUB] 1980. 113 p.
TK9360.I64 1980, v. 6

Working Papers

----- International plutonium policy. [Vienna, International Atomic Energy Agency, available from NTIS] 1978. 8 p.
"INFCE/DEP/WG-4/107"

----- Proliferation resistance assessment of nuclear systems. [Vienna, International Atomic Energy Agency, available from NTIS] 1978. 47 p.
"INFCE/DEP/WG-8/91"

----- Safeguarding a future industrial reprocessing plant. [Vienna, International Atomic Energy Agency, available from NTIS] 1978. 15 p.
"INFCE/DEP/WG-4/118"

----- Safeguarding future large-scale plutonium bulk handling facilities; report to Working Group 4. Vienna, International Atomic Energy Agency [available from NTIS] 1979. 23 p.
"INFCE/DEP/WG-4/117"

International nuclear safeguards. International Atomic Energy Agency bulletin, v. 19, Oct. 1977: 2-22, 24-38, 40-44, 47. QC770.I493, v. 19

Jennekens, J. International safeguards: the quantification issue. International Atomic Energy Agency bulletin, v. 22, Aug. 1980: 41-44. QC770.I493, v. 22

Johnson, Brian. Nuclear power proliferation: problems of international control. Energy policy, v. 5, Sept. 1977: 179-194.

Kapur, Ashok. International nuclear proliferation: multilateral diplomacy and regional aspects. New York, Praeger, 1979. 387 p. JX1974.73.K36

Keepin, G. Robert. Safeguards implementation in the nuclear fuel cycle. Nuclear materials management, v. 7, fall 1978: 44-58.

Kennedy, R. T., and H. E. Lyon. Assurance of the effectiveness of safeguards in light of their objectives. Vienna, International Atomic Energy Agency, [available from NTIS] 1977. 14 p.
"IAEA-CN-36/414"
Presented at the International Conference on Nuclear Power and Its Fuel Cycles, Salzburg, Austria, 1977.

Kovan, Dick. Safeguarding a plutonium industry. Nuclear engineering international, v. 23, Aug. 1978: 41-45. TK9001.N75, v. 23

Kratzer, Myron B. International safeguards for reprocessing plants; final report, by M. Kratzer and others. Washington, International Energy Associates, 1981. 157 p.
"ORNL/SUB-7605/12-1"

----- International safeguards for spent fuel storage, by M. Kratzer and others. Oak Ridge, Tenn., Oak Ridge National Laboratory [available from NTIS] 1981. 73 p.
"ORNL/SUB-7605/12-2"

----- Nuclear cooperation and non-proliferation. Atomic energy law journal, v. 17, winter 1976: 250-288. LAW

Lovett, J. E. Development of the safeguards approach for reprocessing plants, by J. E. Lovett and T. Shea. In Symposium on Nuclear Material Safeguards, Vienna, 1978. Nuclear safeguards technology 1978: proceedings. Vol. 2. Vienna, International Atomic Energy Agency, 1979. p. 583-592. TK9153.S935 1978, v. 2

----- Nuclear materials: accountability, management, safeguards, by James E. Lovett. Hinsdale, Ill., American Nuclear Society, 1974. 298 p. TK9400.L65

Management of nuclear materials. Ralph F. Lumb, editor. Princeton, N.J., Van Nostrand, 1960. 516 p. HD9698.U52L8
"Prepared under auspices of the Office of Technical Information, United States Atomic Energy Commission."

Marshall, W. To judge the degree of proliferation resistance, by W. Marshall and S. Tamiya. Vienna, International Nuclear Fuel Cycle Evaluation [available from NTIS] 1978. 40 p.
"INFCE/DEP/WG-4/104"

----- Politics, plutonium, and energy interdependence. Electric perspectives, v. 1980, fall 1980: 1-13. HD9685.U4E38, v. 1980

McKnight, Allan D. Atomic safeguards; a study in international verification. New York, United Nations Institute for Training and Research, 1971. 301 p.
JX1974.7.M225

Miller, M. M. Heavy water and nonproliferation. Cambridge, Massachusetts Institute of Technology, Dept. of Nuclear Engineering [available from NTIS] 1980. 179 p.
"DOE/ET/33007-6"

Moglewer, Sidney. IAEA safeguards and non-proliferation. Bulletin of the atomic scientists, v. 37, Oct. 1981: 24-36. TK9145.A84, v. 37

Non-proliferation and safeguards. In International Atomic Energy Agency. Regional nuclear fuel cycle centres. Vol. 2. Vienna, 1977. p. 11-27.
TK9360.I59 1977

Nonproliferation and U.S. foreign policy. Joseph A. Yager, editor. Washington, Brookings Institution, 1980. 438 p. JX1974.73.N66

Nuclear nonproliferation: the spent fuel problem. Frederick C. Williams and David A. Deese, editors. New York, Pergamon Press, 1979. 221 p. (Pergamon policy studies on energy and environment)
TD899.A8N8 1979
Pergamon policy studies, no. 32.

Nye, J. S. Maintaining a non-proliferation regime. International organization, v. 35, winter 1981: 15-38. JX1901.F6, v. 35

Parker, L. International safeguards against the diversion of nuclear materials to non-peaceful uses. International and comparative law quarterly, v. 27, Oct. 1978: 711-737. LAW

----- Psychology of nuclear safeguards, by Lyn Parker. New scientist, v. 79, Aug. 17, 1978: 460-461.

Pendley, Robert, and Lawrence Scheinman. International safeguarding as institutionalized collective behavior. International organization, v. 29, summer 1975: 586-616. JX1901.F6, v. 29

Persiani, P. J. Preliminary considerations on developing IAEA technical safeguards for LMFBR power systems. Argonne, Ill., Argonne National Laboratory [available from NTIS] 1980. 77 p.
"ANL-80-69"

Pigford, T. H., C. S. Yang, and M. Maeda. Denatured fuel cycles for international safeguards. Nuclear technology, v. 41, Nov. 1978: 46-59.

Poch, L. A., and T. D. Wolsko. Review of the nuclear safeguards problem. Argonne, Ill., Argonne National Laboratory [available from NTIS] 1979. 20 p.
"ANL/EES-TM--67"

Present status of IAEA's safeguards on nuclear fuel cycle facilities. International Atomic Energy Agency bulletin, v. 22, Aug. 1980: 2-40.
QC770.I493, v. 22

Rainer, R., and B. Sanders. IAEA's NPT safeguards: national control and international safeguards. In Nuclear proliferation problems. Cambridge, Mass., MIT Press, 1974. p. 133-141. JX1974.7.N82 1974

Rappoport, L., and J. D. Pettinelli. Social psychological studies of the safeguards problem. Manhattan, Kan., Kansas State University [available from NTIS] 1972. 34 p.
"PB-81-112856"

Reynolds, D. A. Concepts on integration of physical protection and material accounting functions in a safeguards systems. Albuquerque, N.M., Sandia National Laboratories [available from NTIS] 1981. 5 p.
"CONF-810706--20"

Rochlin, Gene I. Safeguards, security, and the spread of nuclear weapons. In his Plutonium, power, and politics: international arrangements for disposition of spent nuclear fuel. Berkeley, University of California Press, 1979. p. 131-157. (Science, technology, and the changing world order)
HD9698.A2R59

Rometsch, R. IAEA's activities in safeguarding nuclear materials and in developing internationally acceptable safety codes and guides for nuclear power plants, by R. Rometsch and H. Specter. Transactions of the American Nuclear Society, v. 25, supp. no. 1, 1977: 40. QC770.A47, v. 25

----- International safeguards on the peaceful uses of nuclear material. Nuclear law, no. 13, Apr. 1974: 66-72. LAW

Rotblat, J. Controlling weapons-grade fissile material. Bulletin of the atomic scientists, v. 33, June 1977: 37-43. TK9145.A85, v. 33

Rowen, H. S. Nonproliferation criteria for assessing civilian nuclear technologies. In Sachs, R.G., editor. National energy issues: how do we decide? Plutonium as a test case. Cambridge, Mass., Ballinger, 1980. p. 179-193. HD9502.U52N35

Safeguarding the atom: a Soviet-American exchange. New York, United Nations Association of the United States of America, 1972. 71 p.

Sanders, B. International safeguards and the nuclear proliferation regime, by B. Sanders and R. H. Rainer. Transactions of the American Nuclear Society, v. 27, 1977: 491. QC770.A47, v. 27

----- International safeguards, by B. Sanders and Ha Vinh Phuong. Nuclear law bulletin, no. 18, 1976: 54-66.

----- Safeguards agreements--their legal and conceptual basis, by B. Sanders and R. H. Rainer. In International Conference on Nuclear Power and Its Fuel Cycle, Salzburg, Austria, 1977. Nuclear power and its fuel cycle: proceedings of an International Conference on Nuclear Power and its Fuel Cycle held by the International Atomic Energy Agency in Salzburg, May 2-13, 1977. Vienna, IAEA [New York, sold by UNIPUB] 1977. v. 7. p. 395-410. (International Atomic Energy Agency. Proceedings series) TK9006.I4763 1977

----- Safeguards against nuclear proliferation, by Benjamin Sanders. Cambridge, Mass., MIT Press, 1975. 114 p. JX1974.7.S214

Scheinman, Lawrence. Nuclear development and international safeguards: where do we stand and where are we going? Nuclear materials management, v. 8, proceedings issue, 1979: 14-22.
Paper presented at the 20th annual meeting of the Institute of Nuclear Materials Management, Albuquerque, N.M., 1979.

Schleicher, H. W. Nuclear safeguards in the European Community: a regional approach. International Atomic Energy Agency bulletin, v. 22, Aug. 1980: 45-50. QC770.I493, v. 22

Sellers, T. A. Preliminary concepts for detecting diversion of light-water reactor spent fuel. In Symposium on Nuclear Material Safeguards, Vienna, 1978. Nuclear safeguards technology 1978: proceedings. Vol. 2. Vienna, International Atomic Energy Agency, 1979. p. 565-578. TK9153.S935 1978, v. 2

Shipley, James P. The structure of safeguards systems. Los Alamos, N.M., Los Alamos Scientific Laboratory [available from NTIS] 1978. 20 p.
"LA-7337-MS"

Smart, Ian. Non-proliferation policies; a possible future framework. In Uranium and nuclear energy: proceedings of the fourth international symposium held by the Uranium Institute, London, September 10-12, 1979. Edited and published by Mining Journal Books Limited in co-operation with the Uranium Institute. London, Mining Journal Books, 1980. p. 268-289. TN490.U7U7

Stanford, Joseph S. Nuclear assistance and cooperation agreements: some problems in the application of safeguards. Journal of international law and economics, v. 10, Aug.-Dec. 1975: 437-451. LAW

Stencel, Sandra. Nuclear safeguards. [Washington] Editorial Research Reports, 1974. 867-884 p. (Editorial research reports, 1974, v. 2, no. 19) HE35.E35 1974, v. 2

Stockholm International Peace Research Institute. The NPT: the main political barrier to nuclear weapon proliferation. London, Taylor & Francis, 1980. 66 p. JX1974.73.S76 1980a

Sweet, William. Controlling nuclear proliferation. Washington, Congressional Quarterly, 1981. 511-531 p. (Editorial research reports, 1981, v. 2, no. 2) H35.E35 1982, v. 2

Symposium on Progress in Safeguards Techniques, Karlsruhe, 1970. Safeguards techniques. Proceedings of a symposium . . . organized by the International Atomic Energy Agency and held in Karlsruhe, July 6-10, 1970. Vienna, International Atomic Energy Agency, 1970. 2 v. (International Atomic Energy Agency. Proceedings series) TK9360.S817 1970

Symposium on the Safeguarding of Nuclear Materials, Vienna, 1975. Safeguarding nuclear materials: proceedings of a Symposium on the Safeguarding of Nuclear Materials organized by the International Atomic Energy Agency and held in Vienna, Oct. 20-24, 1975. Vienna, The Agency; New York, Sold by Unipub, 1976. 2 v. (International Atomic Energy Agency. Proceedings series) HD9698.A2S945 1975

Szasz, Paul C. The adequacy of international nuclear safeguards. Journal of international law and economics, v. 10, Aug.-Dec. 1975: 423-436. LAW

The Technical objectives of safeguards. International Atomic Energy Agency bulletin, v. 17, Apr. 1975: 13-17. QC770.I493,-v. 17

U.S. Atomic Energy Commission. Office of Safeguards and Materials Management. Safeguards paper from ANS/AIF winter meeting, Nov. 1968. Washington, For sale by the Supt. of Docs., U.S. Govt. Print. Off., 1970. 160 p.
"WASH-1149"

U.S. Congress. Office of Technology Assessment. Nuclear proliferation and safeguards. [Washington] 1977. 2 v. in 3. UF767.U52 1977

U.S. Congress. Senate. Committee on Foreign Relations. IAEA programs of safeguards. Hearing, 97th Cong., 1st sess. Dec. 2, 1981. Washington, U.S. Govt. Print. Off., 1982. 104 p.

----- IAEA Safeguards Agreement. Hearing, 96th Cong., 1st sess. June 22, 1979. Washington, U.S. Govt. Print. Off., 1979. 196 p. KF26.F6 1979u
"Ex. B, 95-2, Agreement with the International Atomic Energy Agency for the application of safeguards in the United States."

----- U.S.-IAEA Treaty; report on the U.S.-International Atomic Energy Agency Safeguards Treaty [to accompany Ex. B, 95-2]. Washington, U.S. Govt. Print. Off., 1980. 72 p. (96th Cong., 2d sess. Senate. Executive report no. 96-42)

U.S. Congress. Senate. Committee on Foreign Relations. Subcommittee on Arms Control, International Organizations and Security Agreements. Nonproliferation issues. Hearings, 94th Cong., 1st and 2d sess. Washington, U.S. Govt. Print. Off., 1977. 426 p. KF26.F628 1975a
Hearings held Mar. 19-Oct. 24, 1975; Feb. 23-Nov. 8, 1976.

U.S. Congress. Senate. Committee on Governmental Affairs. Subcommittee on Energy, Nuclear Proliferation and Federal Services. Office of Technology Assessment report on nuclear proliferation safeguards. Hearing, 95th Cong., 1st sess. Apr. 4, 1977. Washington, U.S. Govt. Print. Off., 1977. 83 p. KF26.G6728 1977

U.S. General Accounting Office. Alternative methods for funding U.S. support of International Atomic Energy Agency activities, Department of State and other Federal agencies; report of the Comptroller General of the United States. Washington, U.S. Govt. Print. Off., 1977. 50 p.
"ID-77-20, May 5, 1977"

----- Assessment of U.S. and international controls over the peaceful uses of nuclear energy; report to the Congress by the Comptroller General of the United States. [Washington] 1976. 131 p. JX1974.7.U56 1976
"ID 76-60, Sept. 14, 1976"

----- An evaluation of the Administration's proposed nuclear non-proliferation strategy; report to the Congress by the Comptroller General of the United States. [Washington] 1977. 70 p.
"ID-77-53, Oct. 4, 1977"

----- Nuclear fuel reprocessing and the problems of safeguarding against the spread of nuclear weapons; report to the Congress by the Comptroller General of the United States. [Washington] 1980. 65 p. HD9698.U52U55 1980
"EMD-80-38, Mar. 18, 1980"

----- The Nuclear Non-Proliferation Act of 1978 should be selectively modified; report to the Congress by the Comptroller General of the United States. [Washington] 1981. 226 p.
"OCG-81-2, May 21, 1981"

----- Role of the International Atomic Energy Agency in safeguarding nuclear material, Department of State, Energy Research and Development Administration; report to the Committee on International Relations, House of Representatives by the Comptroller General of the United States. [Washington] 1975. 44 p.
"ID-75-65, July 3, 1975"

U.S. Library of Congress. Congressional Research Service. Nuclear safeguards: an updated analysis of the concept of safeguards as a national and international institution; report prepared for the Subcommittee on Energy and Production of the Committee on Science and Technology, U.S. House of Representatives. Washington, U.S. Govt. Print. Off., 1980. 50 p.
"Serial VV" HD9698.U52U57 1980a
At head of title: Committee print.

U.S. Nuclear Regulatory Commission. Joint ERDA-NRC task force on safeguards; final report [by the] Nuclear Regulatory Commission and the Energy Research and Development Administration. Washington [Available from NTIS] 1976. 78 p.
"PB-263 365/9G1", "NUREG--0095", "ERDA--77-34"

----- Report of the Material Control and Material Accounting Task Force. Washington [available from NTIS] 1978. 5 v.
"NUREG-0450", "PB-280 328/6G1", "PB-280 329/4G1", "PB-280 331/0G1"

U.S. President, 1977-1981 (Carter). Agreement with the International Atomic Energy Agency for the application of safeguards in the United States of America, with protocol; message. Washington, U.S. Govt. Print. Off., 1978. 33 p. (95th Cong., 2d sess. Senate. Executive B)

Uranium Institute. Bilateral agreements and the evolution of the international safeguards system. London, 1981. 15 p.

Von Baeckmann, A. The application of modern methods and techniques in safeguards operations. International Atomic Energy Agency bulletin, v. 23, Mar. 1981: 15-19. QC770.I493, v. 23

Warnecke, Steven J. Non-proliferation and INFCE: an interim assessment. Survival, v. 21, May-June 1979: 116-124. U162.S9, v. 21

Weiss, Leonard. Nuclear safeguards: a congressional perspective. Bulletin of the atomic scientists, v. 34, May 1978: 27-33. TK9145.A84, v. 34

Williams, Frederick, and others. The Nuclear Non-Proliferation Act of 1978. International security, v. 3, fall 1978: 44-66. JX1901.I67, v. 3

Willrich, Mason. International safeguards and nuclear industry, Mason Willrich, editor. Baltimore, Johns Hopkins University Press, 1973. 307 p. HD9698.A2W53

----- Nuclear theft: risks and safeguards; a report to the Energy Policy Project of the Ford Foundation, by Mason Willrich and Theodore B. Taylor. Cambridge, Mass., Ballinger, 1974. 252 p. HD9698.A2W54

Yager, Joseph A. International cooperation in nuclear energy. Washington, Brookings Institution, 1981. 226 p. HD9698.A2Y34

Yolken, H. T. Possibilities for international co-operation in standardizing measurement methods for nuclear safeguards. In Symposium on Nuclear Material Safeguards, Vienna, 1978. Nuclear safeguards technology 1978: proceedings. Vol. 2. Vienna, International Atomic Energy Agency, 1979. p. 243-249. TK9153.S935 1978, v. 2

Zebroski, E. L. Paths to a nuclear world with reliable safeguards. In Conference on Spent Fuel Policy and Its Implications; executive conference proceedings. La Grange Park, Ill., American Nuclear Society, 1978. p. 31-46. TK9360.E93 1978

BACKGROUND PAPER ON INTERNATIONAL NUCLEAR SAFEGUARDS

The International Atomic Energy Agency (IAEA) was created in 1957 to accelerate and enlarge the contribution of nuclear energy to peace, health, and prosperity throughout the world without furthering any military purpose. One of its responsibilities is to administer an international safeguards system.

The desired effects of IAEA safeguards are to (1) deter, through prompt detection, national diversions of safeguarded nuclear material; (2) place responsibility on the host country for instituting domestic programs to guard against subnational diversions (such as individuals or groups acting contrary to government policy); (3) reduce specific international tensions by providing a degree of assurance among countries, especially hostile neighbors, that the safeguarded country is not developing nuclear explosive devices; and (4) insure that international nuclear commerce can be freely conducted without contributing to insecurity and tension among nations.

As the number of nations accepting IAEA safeguards has increased, the challenges to IAEA have also grown. In recent years, there has been a great increase in the number of facilities subject to safeguards. IAEA is now responsible for the application of safeguards at new types and sizes of facilities central to the question of weapons proliferation. These facilities include enrichment plants, large reprocessing facilities, and plants for fabricating mixed uranium-plutonium oxide fuel for power reactors and highly enriched uranium for research reactors. In addition, IAEA is now required to deal with complete nuclear fuel cycles within single countries or close international groupings of countries.

The following tables reflect IAEA figures on the growth phenomena in the number of facilities and the quantities of nuclear material under Agency safeguards in non-nuclear weapon countries.

Table 1

NUCLEAR INSTALLATIONS UNDER IAEA SAFEGUARDS OR CONTAINING SAFEGUARDED MATERIAL

Type of facility	1975	1980
Power reactors	43	127
Research reactors and critical assemblies	103	175
Conversion, fuel fabrication, reprocessing, and enrichment plants	29	53
Others	140	419
Total	315	774

Table 2

NUCLEAR MATERIAL UNDER IAEA SAFEGUARDS IN NON-NUCLEAR WEAPON NATIONS

	1975	1980
	---- (metric tons) ----	
Plutonium	17	83
Uranium enriched to 20% or more	4	11
Uranium enriched to less than 20%	3,091	13,872
Source materials (natural or depleted uranium and thorium)	4,440	19,097

The objective of IAEA safeguards is to provide

> " * * * timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or other nuclear explosive devices or for purposes unknown, and deterrence of such diversion by the risk of early detection."

In 1979, IAEA established detection goals in which it defined a significant quantity of nuclear material as the approximate amount needed to construct a nuclear explosive device. According to IAEA, timely detection refers to the ability to identify any diversion within the approximate time needed to convert nuclear material into the fissile component of a nuclear explosive device.

Table 3 below shows IAEA's significant quantities and conversion times for various types of nuclear material.

Table 3

QUANTITIES OF NUCLEAR MATERIAL SIGNIFICANT FOR WEAPONS AND APPROXIMATE TIME TO CONVERT FOR USE IN NUCLEAR EXPLOSIVES

Material	Amount (kilograms)	Time starting with	
		Pure material	Irradiated fuel
Plutonium/Uranium 233	8	7 to 10 days	1 to 3 months
Highly Enriched Uranium	25	7 to 10 days	1 to 3 months
Low Enriched Uranium	75	1 year	1 year

As illustrated above, the amount of plutonium and highly enriched uranium under safeguards in the non-nuclear weapon countries is potentially enough to develop several thousand nuclear explosive devices.

IAEA's safeguards system depends upon material accountability, complemented by containment and surveillance devices. In applying safeguards IAEA considers (1) a review of the design of the nuclear facilities, (2) a review of facilities' material records and reports submitted by the involved country, and (3) inspection and surveillance of the facilities.

Reviewing the facility design enables IAEA to determine the character, purpose, capacity, and layout of the facility. Then, after consulting the country, IAEA selects which surveillance techniques and containment devices, such as cameras and seals, if any, are to be employed; selects key points for measuring material flows and inventories; and establishes requirements for records and reports. Decisions on what safeguards will be implemented are to a large degree related to the amount and type of nuclear material handled at the facility.

The starting point for an actual inspection, according to IAEA officials, is the inventory data submitted by the country. Changes in the inventory since the last inspection based on receipt, production, consumption, and transfer notices are recorded. This inventory then becomes the basis for verification. To verify inventory, IAEA inspectors may count, weigh, and measure the material; take samples for independent analysis; and inspect previously applied seals and make comparisons with the accounting records.

STATUS OF SAFEGUARDS

International safeguards are a cornerstone of the nonproliferation regime. Assurance of safeguards effectiveness is considered mandatory for continued use of nuclear power. In essence, the United States and other nations around the world have placed great trust and reliance in the international safeguards system to deter would-be diverters and provide timely warning if safeguarded nuclear material is diverted from peaceful nuclear activities. Moreover, it is important to note the following facts about the scope of international safeguards.

- --The vast majority of nuclear facilities and material in non-nuclear weapons nations is subject to IAEA safeguards. However, membership in IAEA does not obligate a country to accept safeguards on all its facilities. For example, India, Israel, and South Africa have facilities not subject to IAEA safeguards. Argentina and Pakistan are developing facilities which apparently will not be safeguarded.

--Nuclear facilities of nuclear weapons countries are not subject to IAEA safeguards except on a voluntary basis. Of the nuclear weapons nations, the United Kingdom, France, and the United States have agreed to place their facilities--except those of direct national security significance--under IAEA safeguards. However, nuclear facilities in the Soviet Union and the People's Republic of China are not under safeguards. China is not even a member of IAEA.

--IAEA inspectors do not have unlimited access on their inspections. They have no authority to pursue or recover diverted material. IAEA safeguards are not designed or intended to search for undeclared or clandestine facilities.

--If an IAEA inspector cannot verify the non-diversion of nuclear material, the country must be given a "reasonable time" to take corrective action, before procedures for non-compliance may be initiated. Such procedures may include notification of member nations and the United Nations as well as the recall of IAEA-sponsored material. Although IAEA has never used these procedures, it seems clear that by the time sanctions could be applied, the country might have had sufficient time to complete its weapons development.

IAEA has reported that it has not detected any discrepancy which would indicate the diversion of a significant amount of safeguarded nuclear material, and has concluded that all such material remains in peaceful nuclear activities or is otherwise adequately accounted for. However, the degree of confidence that can be associated with current IAEA safeguards depends on such things as the amount, scope, and nature of the inspection effort.

International safeguards have reached different degrees of development for different types of facilities, in part, because IAEA experience in safeguarding certain types is considerably greater than for others. For example, IAEA has experience in safeguarding thermal power reactors (particularly light water reactors), but limited experience in safeguarding fast breeder reactors. Also, IAEA has experience in safeguarding certain bulk handling facilities--conversion and fabrication plants--but limited experience in applying safeguards to reprocessing and enrichment plants, which are key to the proliferation issue because they provide direct access to weapons-usable material. IAEA has had limited experience in safeguarding such facilities because they are relatively few in number and until recently, were not under IAEA safeguards.

It is generally recognized that new procedures and techniques must be developed to meet the safeguard challenges presented by these larger and more complex facilities that have come under safeguards in recent years. Large amounts of material in various forms present in or flowing through "bulk handling" facilities have been cited as posing substantial problems for IAEA inspectors.

The adequacy of IAEA safeguards has been increasingly challenged in recent months. In general terms, IAEA and U.S. officials admit that IAEA inspectors have experienced some difficulty in meeting the Agency's timely detection goals at certain facilities. U.S. and IAEA officials also agree that the general effectiveness of IAEA safeguards has been adversely influenced by several factors, including (1) a limited number of inspectors, and (2) a lack of suitable techniques and equipment. This background paper concentrates on the issue of techniques and equipment for material accountability and for containment and surveillance.

MATERIALS ACCOUNTANCY

There are only a few types of facilities at which IAEA can fully base its safeguards conclusions on quantitative verification of material, while there are many areas where the inspector must rely on semi-quantitative measures or qualitative measures such as containment and surveillance devices. The ability to measure essentially all forms of material in the nuclear fuel cycle is necessary if quantitative conclusions are to be drawn from IAEA inspections.

As part of its independent verification of nuclear material, IAEA may take and analyze samples where appropriate. However, IAEA has been making greater use of non-destructive measurement instruments, especially ones which an inspector can carry with him and calibrate on-the-spot. In general, non-destructive assay is less expensive, less time-consuming, and often may be less hazardous than destructive analysis. In some cases, destructive sampling is unacceptable because it would destroy valuable material while non-destructive assays can be repeated on-site without harming the material.

However, a substantial amount of material is in forms that are currently unmeasurable, and other material cannot be reliably measured. The exact quantity of nuclear material or its isotopic content cannot be accurately determined in some situations. For example, material inside reactors and irradiated material is not quantitatively measured.

Because the existing equipment cannot precisely determine the amount of material on hand, there can be no assurance that every loss will be detected. This decreases the ability to detect potential diversion when large amounts of nuclear material are handled. Even when measurement uncertainties are less than 1 percent, such equipment may be unable to assure whether or not a diversion of a few kilograms of material had occurred if facilities process large amounts of material.

CONTAINMENT AND SURVEILLANCE

As complementary measures to its material accountability verifications, IAEA relies on containment and surveillance systems to enhance the probability of detecting the removal of material, through a combination of physical barriers, seals, and optical and instrumental surveillance devices. Although such systems alone cannot detect and verify diversions because they do not quantify material flows, they should (1) help to maintain the integrity of material accountability data by ensuring that all material flows by key measurement points, (2) indicate tampering with safeguards equipment, and (3) indicate unusual process-operating conditions.

Containment and surveillance devices such as seals, TV monitors, and cameras are not considered reliable for assuring the continued integrity of material control and accountability. For example, cameras used by IAEA in many cases have not been adequate--film jamming and camera failure have not been uncommon.

BUDGET

The $86.3 million regular (assessed) budget of IAEA for 1982, which was approved in September 1981, includes $25.7 million for its safeguards activities. Of the $25.7 million for safeguards, IAEA has allocated $1.6 million for the procurement of scientific supplies and equipment for safeguards. The preliminary estimates shown in an IAEA 1982 budget document project $4.0 million for that purpose in each of 1983 and 1984. (See attach. I.)

IAEA estimates that the cost of this new safeguards equipment through 1985 will be about $20 million with an additional $10 million for maintenance and consumable supplies (e.g., seals and films). With inflation, IAEA officials believe the total cost for equipment, maintenance, and supplies would be about $40 million through 1985.

If sophisticated safeguards equipment is provided by the United States and a few others, and adequate IAEA financial resources are not set aside for the replacement and maintenance costs, then IAEA dependence on special support programs may further increase.

The United States has encouraged other member nations to render special assistance to IAEA in the technical aspects of safeguards. To date, only a few countries have initiated such programs, but a a few others are considering doing so.

U.S. EFFORTS TO UPGRADE INTERNATIONAL SAFEGUARDS

To help IAEA upgrade its safeguards system, President Ford, in 1976, pledged $1 million of special help annually for 5 years. In line with the President's pledge, the Departments of State and Energy, the Arms Control and Disarmament Agency, and the Nuclear Regulatory Commission initiated a program of coordinated actions in support of IAEA safeguards, including the Program of Technical Assistance to Safeguards (POTAS). This technical assistance program was intended to provide quick reaction to urgent needs, as identified by IAEA, to improve safeguards effectiveness where normal IAEA budget channels could not respond fast enough.

From fiscal year 1977 through fiscal year 1981, the United States provided about $23 million through this special technical assistance program to improve international safeguards. In addition, the Department of Energy, the Arms Control and Disarmament Agency, and the Nuclear Regulatory Commission each have their own programs designed to support international safeguards. Since 1977, these agencies have expended a total of about $30.6 million on these programs. (See attach. II.) Nevertheless, U.S. officials stressed that the POTAS program has become the main vehicle for providing technical resources, funds, and other support to improve international safeguards as envisioned by the Nuclear Non-Proliferation Act of 1978.

Through POTAS, the United States had agreed to undertake 329 specific projects, each of which had been requested by IAEA in order to improve a particular aspect of its safeguard functions. Over 200 of those projects had been completed by the United States by the end of 1981. The assistance provided to IAEA includes (1) equipment and standards, (2) experts, (3) system studies, (4) techniques, procedures, and equipment evaluation, and (5) training. Of the $23 million provided through 1981, about 40 percent was allocated to about 70 projects involving the development of equipment and standards.

According to U.S. officials, a significant achievement of POTAS has been the development of reliable, easy to use, and, where required, tamper-resistant safeguards equipment. Twenty-one different types of such devices have been developed by various United States national laboratories and private contractors. (See attach. III.) However, DOE officials advised us that about half of the 21 types of equipment developed through POTAS have been placed into routine use by IAEA. The current emphasis of POTAS is on assistance aimed at placing equipment and techniques into routine use.

Examples of other U.S. projects designed to assist IAEA safeguards are TASTEX, RECOVER, and PAT-2.

TASTEX

The International Safeguards Project Office of the Brookhaven National Laboratory, in addition to administering POTAS under contract with the Department of Energy, also administered the development by the United States of advanced equipment and techniques in the Tokai Advanced Safeguards Technology Exercise (TASTEX) program for the application of IAEA safeguards to the nuclear fuel reprocessing facility at Tokai Mura, Japan. France, Japan, and IAEA also participated in that program, which was completed in May 1981. A number of instruments developed by the United States are being put into use for IAEA safeguards at Tokai Mura.

RECOVER

ACDA has undertaken a project to develop a communication system for the REmote COntinual VERification (RECOVER) of the status of safeguards devices installed at nuclear facilities throughout the world. The function of RECOVER is to provide IAEA with timely centralized reporting of operational failure of, or tampering with, IAEA safeguards devices. Such reporting, according to ACDA, could be useful to IAEA in increasing the safeguards inspectorate's effectiveness and efficiency.

Safeguards devices which could be monitored by RECOVER include: fiber-optic seals, TV or film camera surveillance systems, and unattended containment or surveillance sensors.

As currently envisioned, interrogation of sensors would be directed from IAEA headquarters. According to ACDA officials, the RECOVER system can be programmed to recognize, after each interrogation sequence, certain significant status changes of particular sensors at particular facilities. When such changes are detected, RECOVER would automatically present a notification at IAEA headquarters.

Tests of a small prototype system, linking Vienna with facilities in eight countries, continued in 1982. Also, work on sensor development is currently being performed.

IAEA has not yet accepted RECOVER as a safeguards tool and does not anticipate its availability for routine use for a number of years.

PAT-2

Sandia National Laboratory has developed and tested a lightweight (about 70 pounds) air-transportable, accident-resistant container (PAT-2) for the worldwide shipment of IAEA safeguards samples containing gram-quantities of plutonium. The project was sponsored by the Department of Energy, but some POTAS funds were involved. In September 1981, the U.S. Department of Transportation issued the certificate for its use, pursuant to IAEA safety regulations, and NRC issued a Certificate of Compliance, pursuant to U.S. regulations. PAT-2 opens the way, once other national authorities endorse its certification, for expedited and economic shipment of safeguards samples from the countries where they originate to IAEA's analytical laboratories in Austria and elsewhere.

ASSISTANCE FROM OTHER COUNTRIES

Other IAEA member nations render special assistance to IAEA in the technical aspects of safeguards. (See attach. IV.)

The West German program, for example, consists of 31 projects which will result in studies, provision of experts, services, and development and testing of techniques and equipment. The program includes work in the areas of (1) systems design and evaluation, (2) data treatment and evaluation, (3) measurement methods and techniques, (4) training of IAEA staff, (5) cost-free experts, and (6) developing and testing of containment and surveillance equipment.

The Canadian support program, initiated in 1978, is a coordinated effort for the development and application of safeguards instruments and techniques for Canadian heavy water reactors with on-line refuelling. It has been funded at about $2 million annually. The program consists of 33 projects to provide (1) manpower assistance including cost-free experts, (2) systems studies to develop safeguards schemes for different types of Canadian facilities, (3) equipment to assist in spent fuel and surveillance projects, and (4) the results of miscellaneous tasks concerning such subjects as heavy water control and physical standards.

COMPARISON OF IAEA'S SCIENTIFIC SUPPLIES AND EQUIPMENT BUDGET TO ITS SAFEGUARDS BUDGET AND TOTAL BUDGET, 1972 THROUGH 1982

	Scientific supplies and equipment component of safeguards budget	Safeguards portion of total budget	Total budget (note c)	Percent for safeguards of total budget
	------ (in millions) ------			
1972	$ .3	$ 2.5	$ 20.3	12.3
1973	.3	2.9	23.4	12.4
1974	.5	3.9	29.3	13.3
1975	.4	5.2	38.0	13.7
1976	.6	6.4	44.1	14.5
1977	.8	8.0	44.7	17.9
1978	.5	12.2	52.5	23.2
1979	.6	16.8	75.4	22.3
1980	.8	19.4	88.1	22.0
1981	1.1 a/	26.4	114.8	23.0
1982	1.6 b/	27.6	115.7	23.9

a/Adjusted budget.

b/Estimate.

c/Includes Regular Budget, Technical Assistance Fund, and Extra-Budgetary Resources.

Source: IAEA's "The Agency's Budget" for each year.

U.S. SUPPORT TO INTERNATIONAL SAFEGUARDS
(000 omitted)

	1977	1978	1979	1980	1981	TOTAL
U.S. assessed share of IAEA safeguards budget	$ 2,323	$ 3,662	$ 4,637	$ 6,007	$ 6,831	$ 23,460
Additional Support						
DOE	2,400	3,400	4,500	7,135	6,600	24,035
ACDA	406	1,887	959	1,600	1,250	6,102
NRC	-	149	88	175	80	492
POTAS	5,420	3,800	5,575	4,100	4,100	22,995
Subtotal	$ 8,226	$ 9,236	$11,122	$13,010	$12,030	$ 53,624
Total	$10,549	$12,898	$15,759	$19,017	$18,861	$ 77,084

IAEA SAFEGUARDS EQUIPMENT IN USE OR UNDER TESTING

Device	Implementation Status	Application
BSAM	In Use	NDA-Unirradiated U and Pu*
Hand Held Ge	In Use	NDA-Unirradiated U and Pu
SAMson	AFU a/	NDA-Unirradiated U and Pu
Mini-MCA	T & E b/	NDA-Unirradiated U and Pu
HLNCC	In Use	NDA-Pu and MOX
AWCC	In Use	NDA-HEU
COLLAR	In Use	NDA-Unirradiated fuel assemblies
Microcomputer	T & E	NDA-Pu and MOX
SGS	In Use	NDA-Pu scrap and waste
Semiportable Load Cell	AFU	Mass of UF_6 Cylinders
ION-1	AFU	NDA-Irradiated Fuel
JAVELIN	In Use	Cerenkov light-irradiated fuel
ITI Underwater Viewer	AFU	Serial Number on irradiated fuel
Semiautomatic Film Scanner	In Use	Reviewing surveillance film
Battery Operated TV	T & E	Optical surveillance
STAR	AFU	Optical surveillance
Reactor Power Monitor	In Use	Monitoring power reactor operation
Calorimeters	In Use	NDA-Pu and MOX
Electronic Seals	In Use	Safeguards seal
Type X Seals	AFU	Safeguards seal
Improved Type E Seals	In Use	Safeguards seal

a/Available for use.

b/T & E - Test and Evaluation conducted by IAEA staff.

*NDA - Non-destructive Assay.

Source: Brookhaven National Laboratory.

ATTACHMENT IV ATTACHMENT IV

OTHER NATIONS' EFFORTS TO UPGRADE SAFEGUARDS

CANADA

FUNDING	TYPE OF ASSISTANCE
1978 - $2 million 1979 - 2 million 1980 - 1 million 1981 - 2 million	Cost-free experts, instrument development, and studies.

OBJECTIVE: Development of a safeguards system for Canadian power reactors which discharge plutonium in spent fuel while at power. Funding includes costs of developing and installing systems at such reactors in Canada.

FEDERAL REPUBLIC OF GERMANY

FUNDING	TYPE OF ASSISTANCE
1978 - $2 million 1979 - 2 million 1980 - 2 million 1981 - Continuing	Cost-free experts, instrument development, and studies.

OBJECTIVE: U.S. experts advise that the program is in fact directed at areas of special interest to Germany and used to develop German positions and rationales for dealings with the IAEA, for instance, on fast breeder reactors. Tasks include development of system designs, methods for data evaluation and instruments for assay, containment and surveillance of plutonium and other fuels.

AUSTRALIA

FUNDING	TYPE OF ASSISTANCE
1978 - None 1979 - None 1980 - $0.6 million for 1980 - 1982	Cost-free experts, instrument development, and studies.

OBJECTIVE: Primarily directed at development of effective safeguards for a centrifuge enrichment plant with limited assistance in other areas.

COMMISSION OF EUROPEAN COMMUNITIES

FUNDING	TYPE OF ASSISTANCE
Under discussion	Instrument development, and studies.

OBJECTIVE: Several areas of technical assistance. IAEA and European inspectors have closely related missions. Past research and development has been applicable in part to IAEA safeguards.

UNITED KINGDOM

FUNDING	TYPE OF ASSISTANCE
1978 - None	Cost-free experts, instrument development, studies, and training.
1979 - None	
1980 - $1.3 million	
1981 - 1.3 million	

OBJECTIVE: Broadly defined program expected to respond to IAEA requests including emphasis on fast breeder fuel cycle.

JAPAN

FUNDING	TYPE OF ASSISTANCE
1979 - 80 - Estimated at $2 million for Tokai Advance Technology Exercise	Instrument development and evaluation, and studies.
1981 - Informal discussions underway	

OBJECTIVE: Participation in joint program of U.S.-Japan-France-IAEA to develop advanced safeguards techniques using the Tokai Mura Reprocessing Facility as a test bed. Informal Japan-IAEA discussions are underway on follow-on technical support by Japan.

FRANCE

Provides technical information as a participant in Tokai Advance Technology Exercise.

UNION OF SOVIET SOCIALIST REPUBLICS

FUNDING	TYPE OF ASSISTANCE
1978 - None	Training and instrument development.
1979 - None	
1980 and 1981 - $0.5 million/year at official rate of exchange for rubles	

OBJECTIVE: Several areas of technical assistance. Past assistance included training for safeguards officials of member states and development of inspection techniques for fast breeder reactors.

Source: Department of State, January 1981.

Report No. 82-86 S

THE INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA) AND ITS SAFEGUARDS: A FACT SHEET

by
Joseph F. Pilat
Office of Senior Specialists

May 6, 1982

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ABSTRACT

A compilation of selected facts about the International Atomic Energy Agency, its purposes, organization, functions, funding and problems with attention to the authority for and limitations of its international inspection (safeguards) function.

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INTRODUCTION

The International Atomic Energy Agency (IAEA) is largely the creation of an American proposal of President Eisenhower in 1953. Established in 1957, one of its principal functions is to inspect nuclear activities in subscribing states to verify that for some states these are not being used for military purposes, and for other states that these are not used to make nuclear weapons. There are called safeguards. Strong IAEA safeguards are central to U.S. policy to prevent the further spread, or proliferation of nuclear weapons.

Over recent years there have been some doubts about the adequacy of IAEA safeguards. These doubts were strengthened in the aftermath of Israel's bombing and destruction of Iraq's powerful research reactor on June 7, 1981. Many Members of Congress have since then expressed their concern about IAEA safeguards, especially their adequacy for possible commercial production and use of plutonium -- a material usable for nuclear explosives -- as a nuclear fuel. Legislation have been introduced to limit or even cutoff U.S. nuclear exports until IAEA safeguards could be improved.

This fact sheet was prepared to provide summary background on the Agency and its safeguards function. It includes information on the purposes, organization, functions, funding and problems of the Agency, and on the authority for and limitations of its safeguards function.

FACT SHEET

What Is the IAEA?

Established on July 29, 1957, by an international statute, the IAEA is a relatively autonomous international organization affiliated with the United Nations, although it is not under U.N. direction or control. Its headquarters are located in Vienna, Austria.

What Is its Purpose?

Article II of its Statute states that the objective of the IAEA is to "accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world. It shall ensure, so far as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purposes."

What Does It Do?

The IAEA has two main functions: to promote peaceful uses of atomic energy, including technical assistance; and to apply international safeguards when requested. In addition, the IAEA establishes international standards of safety for nuclear energy.

How Is It Organized?

The IAEA has three principle parts:

The General Conference, with representatives of all member states, meets annually to debate general policy and approve programs and budgets, and elects members of the Board of Governors;

The Board, with representatives from 34 nations, is the executive organ of the Agency. It meets about 4 times a year, and considers policy, recommends budgets, appoints a Director-General, approves states for membership; and Secretariat, headed by the Director-General, which administers and implements the Agency's program. The Secretariat is divided into five departments -- Administration, Research and Isotopes, Safeguards, Technical Assistance and Publications, and Technical Operations -- each headed by a Deputy Director-General. The Director-General is advised on scientific and technical matters by a Scientific Advisory Committee of distinguished scientists, whose appointments are for three-year terms and who represent all fields of nuclear science. The Standing Advisory Group on Safeguards Implementation (SAGSI) provides advice on technical aspects of safeguards.

How Is the IAEA Funded?

The IAEA is funded through regular and voluntary contributions from member states, with some income derived from sales of publications and charges for technical assistance. In 1980, the regular budget of the IAEA was $80,643,000, of which $19,363,224 was from the U.S. An estimated $13,829,800, excluding contributions in kind, was voluntarily contributed in 1980. Of this sum, the U.S. contributed $2,451,000.

What Is the Size of the Staff?

At the end of 1980, the Secretariat had a total staff of 1597. Of these 577 were in the professional and higher categories; 865 in the General Service cetageory; and 155 in the maintenance and operations category.

Who Are the Key Officials?

-- Director-General, Hans Blix, Sweden;
-- Deputy Director-General, Department of Administration, Nelson Sievering, United States of America;

-- Director, Division of External Relations, Department of Christoher Herzig, United Kingdom;
-- Director, Division of Public Information, Department of Administration, Georges Delcoigne, Belgium;
-- Deputy Director-General, Department of Safeguards, Hans Gruemm, Austria;
-- Director, Division of Development and Technical Support, Department of Safeguards, Adolf von Baeckmann, Federal Republic of Germany;
-- Director, Division of Safeguards Information Treatment, Department of Safeguards, Lev Issaev, U.S.S.R.;
-- Director, Division of Operations (A), Department of Safeguards, Frantisek Klik, Czechoslovakia;
-- Director, Division of Operations (B), Department of Safeguards, Tohru Haginoya, Japan;
-- Deputy Director-General, Department of Technical Cooperation, Carlos Velez, Mexico;
-- Deputy Director-General, Department of Technical Operations, Boris Semenov, U.S.S.R.; and
-- Deputy Director General, Department of Research and Isotopes, Maurizio Zifferero, Italy.

What Are IAEA Safeguards?

The safeguards administered by the IAEA are a system of recordkeeping, audits, and inspections with national and international components intended to deter the diversion of nuclear materials to military uses and particularly to nuclear weapons or other nuclear explosive devices by imposing risks of discovery and counteraction.

IAEA safeguards for NPT states differ from those for non-NPT states. The purpose of the NPT safeguards is to ensure "the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices... and deterrence of such diversion by risk of early detection." Non-NPT safeguards seek to ensure that nuclear assistance provided by or at the request of the Agency is not used to further any military purpose. NPT safeguards apply to all nuclear facilities and materials for peaceful purposes in any NPT state, with the exception of the nuclear weapons states. Non-NPT safeguards apply only to nuclear facilities and materials that are placed under safeguards by an agreement between the possessing state and the Agency. NPT safeguards focus upon materials throughout the state and emphasize sampling, measurement, and statistical analysis rather than total inspection. They require a national system of accounting for and control of nuclear materials, which the Agency audits and inspects to verify its findings of the national system. Non-NPT safeguards require only those records and reports as agreed upon between the supplier state, the receiving state, and the Agency.

What are the International Bases of IAEA Safeguards?

IAEA Statutes. -- Article III, 5 of the Statute of the IAEA authorizes it:

> To establish and administer safeguards and to apply safeguards upon request to any bilateral or multilateral arrangement or at the request of a State.

Article XII of the Statute provides:

> With respect to any Agency project, or other arrangement where the Agency is requested by the parties concerned to supply safeguards, the Agency shall have the following rights and responsibilities to the extent relevant to the project or arrangement:
>
> 1. To examine the design of specialized equipment and facilities, including nuclear reactors, and to approve it only from the viewpoint of assuring that it will not further any military purposes, that it complies with applicable health and safety standards, and that it will permit effective application of safeguards. . .
>
> 2. To require the observance of any health and safety measures prescrbed by the Agency;
>
> 3. To require the maintenance and production of operating records to assist in ensuring accountability for source and special fissionable materials used or produced in the project or arrangement;
>
> 4. To call for and receive progress reports;
>
> 5. To approve the means to be used for the chemical processing of irradiated materials solely to ensure that this chemical processing will not lend itself to diversion of materials for military purposes and will comply with applicable health and safety standards. . .

6. To send into the territory of the recipient state or states inspectors, designated by the Agency, after consultation with the state or states concerned, who shall have access at all times to all places and data and to any person who by reason of his occupation deals with materials, equipment or facilities which are required by this statute to be safeguarded, as necessary to account for source and special fissionable materials supplied and fissionable products and to determine whether there is compliance with the undertaking against use in furtherance of any military purposes. . . Inspectors designated by the Agency shall be accompanied by representatives of the authorities of the state concerned, if that state so requests, provided that the inspectors shall not thereby be delayed or otherwise impeded in the exercise of their functions.

Treaty on the non-proliferation of nuclear weapons. -- Article III of the NPT states:

1. Each non-nuclear weapon State Party to the Treaty undertakes to accept safeguards, as set forth in an agreement to be negotiated and concluded with the International Atomic Energy Agency in accordance with the Statute of the International Atomic Energy Agency and the Agency's safeguards system, for the exclusive purpose of verification of the fulfillment of its obligations assumed under this Treaty with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices. Procedures for the safeguards required by this article shall be followed with respect to source or special fissionable material whether it is being produced, processed or used in any principal nuclear facility or it outside any such facility. The safeguards required by this article shall be applied on all source or special fissionable material in all peaceful nuclear activities within the territory of such State, under its jurisdiction, or carried out under its control anywhere.

2. Each State Party to the Treaty undertakes not to provide: (a) source or special fissionable material, or (b) equipment or material especially designed or prepared for the processing, use or production of special fissionable material, to any non-nuclear weapon State for peaceful purposes, unless the source or special fissionable material shall be subject to the safeguards required by this article.

3. The safeguards required by this article shall be implemented in a manner designed to comply with article IV of this Treaty, and to avoid hampering the economic or technological development of the Parties or international cooperation in the field of peaceful nuclear activities, including the international exchange of nuclear material and equipment for the processing, use or production of nuclear material for peaceful purposes in accordance with the provisions of this article and the principle of safeguarding set forth in the Preamble of the Treaty.

> 4. Non-nuclear-weapon States Party to the Treaty shall conclude agreements with the International Atomic Energy Agency to meet the requirements of this article either individually or together with other States in accordance with the Statute of the International Atomic Energy Agency . . .

Treaty for the prohibition of nuclear weapons in Latin America (Treaty of Tlatelolco). -- Article XIII of the Treaty of Tlatelolco states:

> Each Contracting Party shall negotiate multilateral or bilateral agreements with the International Atomic Energy Agency for the application of its safeguards to its nuclear activities . . .

How Are IAEA Inspections Made?

On the basis of inventory data submitted by the safeguarded state, inspectors look for changes in the inventory since the last inspection, based on receipt and transfer notices. This book inventory then becomes the basis for inspection. To verify the inventory, IAEA inspectors may count, weigh, measure the material, take samples for independent analysis, perform non-destructive tests, inspect seals, and make comparisons with the accounting records.

What Can IAEA Inspections Do? Not Do?

IAEA inspections can verify inventories of nuclear material, and in principle detect diversion of safeguarded material or misuse of a safeguarded facility on the basis of these inventories. Inspection cannot prevent diversion of safeguarded material, and can do nothing about unsafeguarded material or facilities.

How Extensive Is Application of IAEA Safeguards?

States. -- By February 1981, 113 non-nuclear weapon states were party to NPT. Of these, 78 had negotiated safeguards agreements and 69 of these had entered into force. Of the remaining states, only three had significant nuclear activity, two of which had begun the procedures for bringing their agreements with the Agency into force. Note, however, that, in these three States, all known nuclear activities are under non-NPT safeguards agreements.

In 1980, the Agency was applying safeguards in 11 non-nuclear-weapon states which were not party to NPT -- namely, Argentina, Brazil, Chile, Colombia, Cuba, the Democratic People's Republic of Korea, India, Israel, Pakistan, South Africa, and Spain. In 6 of these 11 countries all substantial nuclear activities of which the Agency was aware were covered by a mosaic of individual safeguards agreements. In 5 of these 11 countries, and a sixth country, which had signed but not yet ratified the NPT, unsafeguarded nuclear facilities were in operation. In only 4 of these 11 countries was the unsafeguarded facility capable of producing weapons-grade material.

During 1980, safeguards were applied in France, the United Kingdom, and the United States of America to nuclear material which was subject to safeguards under agreements with third countries and which had been returned or transferred to those three states.

Facilities. -- The number of plants under safeguards increased during 1980, from 700 to 774; the plants included certain facilities for which very frequent or continuous inspection was needed.

Materials. -- The quantity of separated plutonium under safeguards decreased by 38 percent to 5 metric tons; the quantity of plutonium contained in spent fuel under safeguards rose by 30 percent to 78 tons; the quantity of highly enriched uranium under safeguards remained at 11tons; safeguarded low-enriched uranium and source material rose by 18 percent and 24 percent, respectively, to 13,872 tons and 19,097 tons.

What Is Involved in Application of IAEA Safeguards in the U.S.?

In 1968, President Johnson pledged that the United States would permit the IAEA to apply its safeguards to all nuclear activities in the United States, excluding only those pertaining directly to national security. This pledge was made to neutralize the complaint of some industrial countries party to the NPT who did not have nuclear weapons and who argued that it was unfair for the U.S. nuclear industry not to be under IAEA safeguards. The United States has negotiated a safeguards agreement with the Agency, which President Carter sent to the Senate for approval as a treaty on Feb. 9, 1978. The Senate approved the agreement on July 2, 1980, and it took effect on Dec. 12, 1980. In March 1981, the IAEA selected three commercial nuclear facilities for application of safeguards: Exxon Nuclear Company's fuel fabrication plant at Richland, Washington; Portland General Electric Company's Trojan nuclear power plant near Prescott, Oregon; and Sacramento Municipal Utility District's Rancho Seco nuclear plant station near Sacramento, California. These NRC licenses will have to furnish information about their facilities, submit reports accounting for their nuclear materials, and permit IAEA inspection.

What Is the Staffing for IAEA Safeguards?

In 1980, the safeguards department of the IAEA had a staff of 324.

What Are the Budgets for Safeguards? How Are They Funded?

In 1980, the regular budget for IAEA's safeguards activities was $21,740,000. In addition, estimated contributions for safeguards, excluding contributions in kind, amounted to $1,490,000 from contributions by Australia, Canada, FRG, USSR, and the US. The United States contribution was $800,000. In addition, a number of states offered the Agency contributions in kind consisting of cost-free experts and consultants, requests for fellowships, training courses, and other. U.S. contributions in kind through the Program of Technical Assistance to Safeguards (POTAS) were approximately $5 million in 1980. Oriented toward improving effectiveness of IAEA safeguards, POTAS programs are administered through the Department of Energy by an interagency commission chaired by a Department of State official. They are funded by Department of State appropriations under the Foreign Assistance Act.

Does the IAEA Have Unused Powers?

The IAEA has some powers that it has not used. It has a right to custody over and storage of "excess. . . special fissionable materials recovered or produced as a by-product. . . to prevent stockpiling of these materials. . ." [Statute, Art. XII, 5.]

Recent Problems

Israeli raid. -- On June 7, 1981, Israeli aircraft attacked an Iraqi research reactor located near Baghdad. An unprecedented preemptive strike against an opponent believed to be developing a nuclear weapons capability, the attack shows Israel had little confidence in the international non-proliferation regime. This is likely to increase concern about weaknesses and gaps in that regime, particularly in IAEA safeguards.

Politicization of agency. -- The 25th General Conference (September 1981) showed signs of serious contention and controversy between several groups or blocs of member states. It concluded with a strong drive by Third World States for more key positions in the Secretariat, more membership on the Board of Governors, and for more support for technical assistance. Also, it is informally understood that the present Director-General will be replaced after one 4-year term by someone favored by the Third World. Politicization was also suggested by attempts to remove Israel and South Africa from the Agency. Such politicization itself might erode the perceived effectiveness of the IAEA safeguards system, the credibility of which is a function of political as well as technical factors. Moreover, Third World demands for more money for technical assistance might or might not reduce funds available for safeguards.

IAEA SAFEGUARDS

AN INTRODUCTION

The following States are Members of the International Atomic Energy Agency:

AFGHANISTAN
ALBANIA
ALGERIA
ARGENTINA
AUSTRALIA
AUSTRIA
BANGLADESH
BELGIUM
BOLIVIA
BRAZIL
BULGARIA
BURMA
BYELORUSSIAN SOVIET SOCIALIST REPUBLIC
CANADA
CHILE
COLOMBIA
COSTA RICA
CUBA
CYPRUS
CZECHOSLOVAKIA
DEMOCRATIC KAMPUCHEA
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA
DENMARK
DOMINICAN REPUBLIC
ECUADOR
EGYPT
EL SALVADOR
ETHIOPIA
FINLAND
FRANCE
GABON
GERMAN DEMOCRATIC REPUBLIC
GERMANY, FEDERAL REPUBLIC OF
GHANA
GREECE
GUATEMALA
HAITI
HOLY SEE
HUNGARY
ICELAND
INDIA
INDONESIA
IRAN
IRAQ
IRELAND
ISRAEL
ITALY
IVORY COAST
JAMAICA
JAPAN
JORDAN
KENYA
KOREA, REPUBLIC OF
KUWAIT
LEBANON
LIBERIA
LIBYAN ARAB JAMAHIRIYA
LIECHTENSTEIN
LUXEMBOURG
MADAGASCAR
MALAYSIA
MALI
MAURITIUS
MEXICO
MONACO
MONGOLIA
MOROCCO
NETHERLANDS
NEW ZEALAND
NICARAGUA
NIGER
NIGERIA
NORWAY
PAKISTAN
PANAMA
PARAGUAY
PERU
PHILIPPINES
POLAND
PORTUGAL
QATAR
ROMANIA
SAUDI ARABIA
SENEGAL
SIERRA LEONE
SINGAPORE
SOUTH AFRICA
SPAIN
SRI LANKA
SUDAN
SWEDEN
SWITZERLAND
SYRIAN ARAB REPUBLIC
THAILAND
TUNISIA
TURKEY
UGANDA
UKRAINIAN SOVIET SOCIALIST REPUBLIC
UNION OF SOVIET SOCIALIST REPUBLICS
UNITED ARAB EMIRATES
UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
UNITED REPUBLIC OF CAMEROON
UNITED REPUBLIC OF TANZANIA
UNITED STATES OF AMERICA
URUGUAY
VENEZUELA
VIET NAM
YUGOSLAVIA
ZAIRE
ZAMBIA

The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

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AN INTRODUCTION

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VIENNA, 1981

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FOREWORD

The IAEA Safeguards Information Series is intended to provide information on IAEA safeguards and related subjects. It is hoped that it will be of help to, inter alia, facility operators, design engineers and, since it is not excessively technical, also to certain civil service and external relations staff, and journalists.

The purpose of this third booklet in the Series is to give a general picture of the objectives and methods of safeguards, and of their role in non-proliferation policy.

The two previous booklets published in the IAEA Safeguards Information Series are as follows: IAEA/SG/INF/1 is a Glossary of Safeguards terms providing definitions which may be useful to the reader with a deeper interest in the subject; IAEA/SG/INF/2 is of a more specialized nature containing guidelines for States' Systems of Accounting for and Control of Nuclear Materials.

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NON-PROLIFERATION AND SAFEGUARDS

Historical

The concept of safeguards

Until the Second World War, agreements and treaties between nations generally rested on the good faith of the parties to the agreement, and did not provide for any means to verify that they were fulfilling the obligations they had accepted. The advent of nuclear energy changed this. Since the early 1950s, when States began to trade in nuclear materials and equipment for peaceful purposes, it has become the practice (and is today the invariable practice) for international agreements dealing with the use of nuclear energy to specify a set of 'safeguards' to verify systematically that the State or States concerned will not use the relevant nuclear materials or equipment for purposes or in a manner proscribed by the agreement. In the case of IAEA safeguards the prohibition generally relates to any explosive and any military use of nuclear material, equipment, etc.

This insistence on rigorous *verification* reflects chiefly the fact that nuclear energy can be used for military as well as peaceful purposes and, in particular, that certain nuclear materials can, in addition to their peaceful applications, be used as the explosive charge of nuclear weapons. A breach of the agreement might thus have far-reaching consequences for the parties themselves and for international security in general. The value of nuclear materials (and the radiation risks they may involve) also calls for precise accounting and other verification measures.

The first proposals

Soon after Hiroshima the United States of America proposed to the newly created United Nations that it should set up an international authority that would control all nuclear material throughout the world and all forms of nuclear activity. By its very first Resolution the General Assembly established a United Nations Atomic Energy Commission to study this proposal (known as the Baruch Plan) and to "deal with the problems raised by the discovery of atomic energy". The Soviet Union called for the destruction and prohibition of all atomic weapons before setting up a system of control.

The USA subsequently modified the Baruch Plan; only the sensitive steps in the nuclear fuel cycle (reprocessing and enrichment) should be owned and operated by an international authority while other activities should be subject to safeguards to ensure that they were not turned to military use. Despite these modifications, the Baruch Plan still called for too far-reaching a surrender of natural sovereignty to be accepted at that time.

The negotiations in the United Nations Atomic Energy Commission reached an impasse in the late 1940s and the Commission was dissolved in 1952. Prospects for a world truly free of nuclear weapons faded with the demise of the Commission and attention turned to the more restricted goal of limiting the number of nuclear-weapon States. Of the two concepts inherent in the Baruch Plan, that of safeguards to verify peaceful use survived and eventually became a cornerstone of all international agreements in the nuclear field. The concept of international operation of sensitive facilities did not bear fruit at the time but it was revived thirty years later and it is still being discussed.

The International Atomic Energy Agency

In 1953 the USA proposed the establishment of an International Atomic Energy Agency (IAEA) which would spread the benefits of nuclear technology[1] in return for an undertaking by each Member State to use it for peaceful purposes only and to accept safeguards to verify this undertaking. After three years of negotiations this concept was eventually reflected in a crucial article of the IAEA's statute which authorized it "to establish and administer safeguards designed to ensure that special fissionable and other materials, services, equipment, facilities, and information made available by the Agency or at its request or under its supervision or control are not used in such a way as to further any military purpose and to apply safeguards at the request of the parties, to any bilateral or multilateral arrangement or at the request of a State, to any of that State's activities in the field of atomic energy". The Statute came into force in 1957 and the IAEA began work, at Vienna, in the same year.

At the same time the USA, the USSR and other leading industrial countries began to conclude agreements for the transfer of nuclear technology, plant and material to other countries. Most of these agreements required the importing country to accept the safeguards of the exporter on the items supplied; in other words, to report regularly on the use made of these items and to accept inspectors to verify the use of the material. In 1956 the countries of the European Communities agreed to establish a regional system of safeguards ('Euratom' safeguards).

From 1957 until 1964 little was done to activate the IAEA's safeguards. By the end of that period all five permanent members of the UN Security Council, China, France, the USSR, the USA and the United Kingdom, had tested nuclear weapons. It was clear that neither strict controls on the transfer of technology nor safeguards applied by exporting countries had been effective in preventing the spread of nuclear weapons.

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[1] Although no nuclear power plant was in operation in 1953 it was already foreseen that nuclear power would become a major producer of electricity.

In 1965 the first major step was taken to develop systematically the IAEA's safeguards by adopting a safeguards system to replace an earlier one which covered only reactors. This new system, which was extended in 1966 and 1968 (IAEA document INFCIRC/66 Rev.2), is still applied in safeguards agreements with the 10 non-nuclear-weapon countries that have nuclear programmes and that have not expressly submitted all their nuclear activities to IAEA safeguards as they would have been required to do if they had been parties to the NPT or Tlatelolco Treaty (see below).

Most of the safeguards agreements with these 10 countries have resulted from decisions to transfer to the IAEA the responsibility for applying the safeguards prescribed in earlier bilateral agreements for the supply of nuclear plant and materials. In six of the 10 cases they cover all known nuclear plant in the country concerned, but unlike NPT safeguards (see below) they leave the country legally free to build *unsafeguarded* facilities and to produce *unsafeguarded* nuclear material.

The Treaty on the Non-Proliferation of Nuclear Weapons (NPT)

Prolonged negotiations at the United Nations' Eighteen Nation Disarmament Committee finally bore fruit in 1968 in an agreement on the text of a treaty designed explicitly to prevent the spread of nuclear weapons – the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). The treaty was subsequently endorsed by the General Assembly and entered into force in May 1970.

Each non-nuclear-weapon State that becomes party to the NPT binds itself not to acquire nuclear weapons or other nuclear explosives (Article II). It also binds itself to conclude an agreement with the IAEA for the application of safeguards to all its peaceful nuclear activities with a view to verifying the fulfilment of its obligations under the Treaty (Article III). In return the Treaty recognizes the right of all Parties to participate in the fullest possible exchange of equipment, materials, and scientific and technological information for the peaceful uses of nuclear energy; in other words all Parties are guaranteed full access to peaceful nuclear technology (Article IV). The Parties also undertake to pursue negotiations in good faith towards nuclear disarmament (Article VI) and re-affirm their determination to achieve the discontinuance of all tests of nuclear weapons (Preamble); these commitments obviously apply principally to the nuclear-weapon States themselves, who alone, under the Treaty, may develop and test nuclear weapons.

Several of the concepts reflected in the NPT had already been incorporated into a regional Treaty for the Prohibition of Nuclear Weapons in Latin America, which the Latin American countries had negotiated and opened for signature in February 1967. This treaty is known as the Tlatelolco Treaty after the location in Mexico where it was concluded.[2]

NPT safeguards

To carry out the safeguards obligations assigned to the IAEA by the NPT it was clearly necessary for the IAEA to devise a safeguards system appropriate for the entire fuel cycle of the advanced industrial countries that were expected to join the Treaty. This NPT safeguards system,which was drawn up during 1970 and approved by the IAEA Board of Governors in the same year, is set forth in IAEA document INFCIRC/153 (corrected).

Acceptance of the NPT and the safeguards that go with it obviously entails a significant concession of national sovereignty, and during the first half of the 1970s the issue was debated extensively in the main industrial non-nuclear-weapon States. The interests of the Common Market countries and of Japan were reconciled in safeguards agreements concluded between them and the IAEA. The ratifications of these agreements followed in 1977, thus bringing the main industrial non-nuclear-weapon States under IAEA safeguards.

Meanwhile, in 1974 a nuclear device was exploded by India, which was not then and still in 1981 is not party to the NPT. Furthermore, the nuclear material used for the Indian device had not been under IAEA safeguards. Nevertheless this event led to some doubts about the adequacy of the international safeguards regime and the NPT. These doubts were reflected subsequently in an informal agreement between supplying countries to apply the so-called 'London guidelines' of 1978, and also in United States legislation approved by Congress in 1978 which sought to restrict the export (and use) of reprocessing and other technologies considered to be sensitive. In other words, supply conditions additional to the safeguards of the NPT were imposed. The United States legislation referred to also required the renegotiation of many existing supply agreements.

A division of interest between the supplying countries and receiving countries thus emerged in the mid-1970s. On the initiative of the USA it was accordingly agreed in Washington in 1977 to launch a general international evaluation, without preconditions, of the technical assumptions concerning the development of the nuclear fuel cycle on which the nuclear energy programmes of many countries had been based since the 1950s. This International Nuclear Fuel Cycle Evaluation (INFCE) came to an end in March 1980 after an exhaustive examination of all aspects of the nuclear fuel cycle. From the work of INFCE it was clear that there is no easy technical means of preventing the acquisition of nuclear explosive material nor is it possible to rank various fuel cycles according to the risk of proliferation they entail; proliferation should rather be regarded as a political problem to be dealt with by creating new institutional and internationally acceptable measures and, above all, by improving and strengthening the international safeguards system.

---

[2] The Tlatelolco Treaty is in some respects more comprehensive than the NPT since it is designed to ensure the *total* absence of nuclear weapons in the region that it covers.

In the meantime the IAEA had embarked on a number of studies on additional institutional measures to reduce the risks of proliferation. It had completed a comprehensive study of the benefits and problems involved in setting up multinational fuel cycle centres, in which certain sensitive stages in the nuclear fuel cycle would be owned and operated by groups of nations. Another ongoing study seeks to activate a safeguards measure foreseen in Article XII.A.5 of the Agency's statute under which the IAEA has the authority to require to be deposited with it any excess of plutonium over that needed by the country concerned for use in reactors or research, the object being to prevent the stockpiling of plutonium. The International Plutonium Storage System (IPS) has been studied by an IAEA expert group since 1978; if it is put into effect it will probably be an integral part of the Agency's safeguards system.

A similar study group is looking into questions of international or multinational arrangements for the storage of spent fuel.

In June 1980, after the conclusion of INFCE, the Board of Governors established a Committee on Assurances of Supply (CAS), open to Member States of the Agency, with a view to restoring the stability of the international nuclear supply system under an acceptable non-proliferation regime. The establishment of this Committee reflects the extent to which the questions of nuclear supplies and safeguards have become intimately linked with each other and the fact that today there could be no significant nuclear trade except within the framework of an effective safeguards regime.

The present position

The spread of nuclear technology

By the end of 1980 a total of 253 nuclear power reactors were in operation in 22 countries, providing about 8% of the world's electricity. By 1985, power reactors already under construction will raise this figure to about 17%. In addition, 353 research reactors are in operation or under construction in 49 countries. The spread of nuclear energy has thus been impressive despite a number of setbacks during the last decade (see Figs 1a and 1b).

At the same time the overt spread of nuclear weapons has slowed down. During the decade that began with Hiroshima (1945 – 1954) three nations became nuclear-weapon States; during the next decade (1955 – 1964) two more followed. During the third decade ending in 1974 only one additional nation exploded a nuclear device, as Fig. 1b shows. In other words, the spread of nuclear weapons

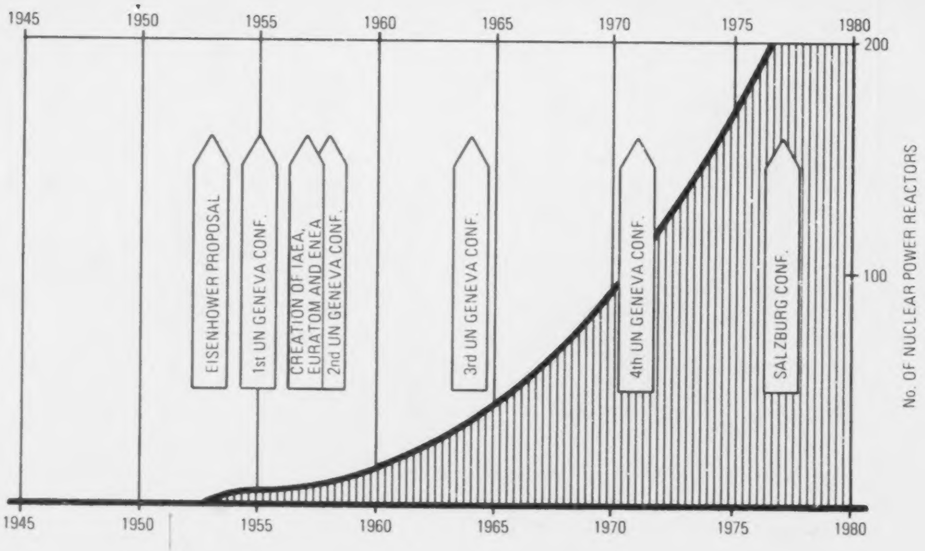

FIG. 1a. Main international steps to promote the peaceful uses of nuclear energy and the growth of nuclear power.

Notes: *(1) The first UN Conference on the Peaceful Uses of Atomic Energy in Geneva in 1955 led to the first major declassification of secret nuclear information. The subsequent conferences continued this tradition, turning with time more to practical technology than to basic science.*

(2) The IAEA International Conference on Nuclear Power and Its Fuel Cycle in Salzburg in 1977 dealt with the overall role to be played by nuclear energy, making particular reference to the fuel cycle and the need for its integration on a national and international level.

(3) Euratom = European Atomic Energy Community. ENEA = European Nuclear Energy Agency: now entitled Nuclear Energy Agency (NEA) of the OECD.

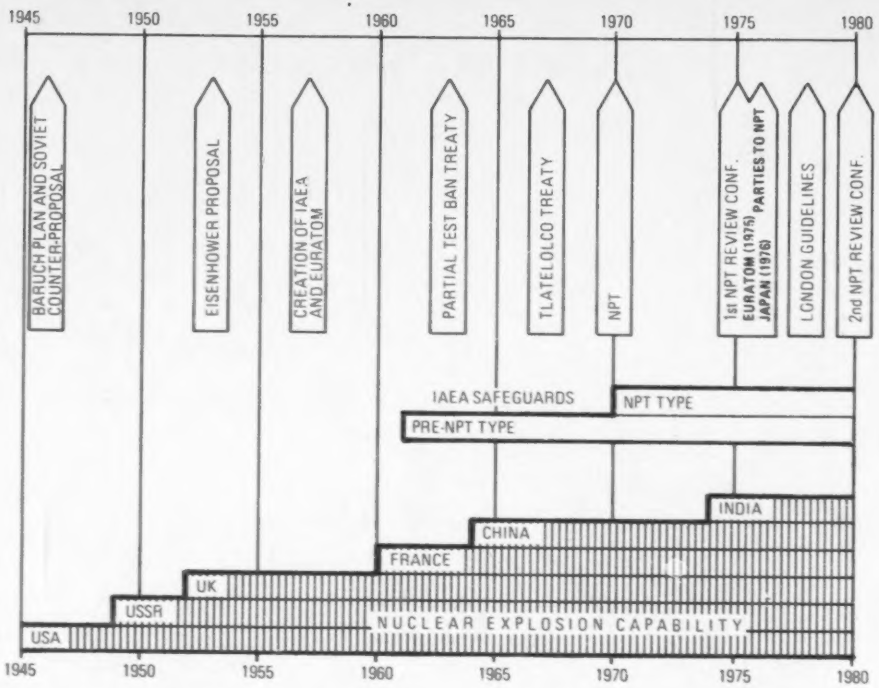

FIG.1b. Main international steps or proposals for stopping the spread of nuclear weapons.

Notes: *(1) The first IAEA Safeguards System (pre-NPT type) was adopted in 1961 to cover nuclear reactors with less than 100 megawatts thermal output. In 1964 this system was extended to cover all nuclear reactors. A second IAEA Safeguards System (also pre-NPT type), adopted in 1965, replaced the first and is still applied. It covers nuclear reactors and, by extensions in 1966 and 1968 also reprocessing, conversion and fuel fabrication plants.*

(2) In addition to the second IAEA Safeguards System there exist provisions (NPT type) for the application of safeguards to all peaceful nuclear activities in the non-nuclear-weapon States parties to the NPT.

and nuclear explosives has, at least so far, slowed down while knowledge of how to make them has become widespread.[3]

There are many reasons for this. It was for instance the Second World War that laid the basis for the US, USSR, UK and French nuclear weapons programmes and that led to the treaties and national laws which make it illegal for the Federal Republic of Germany and Japan as well as several other European countries to acquire nuclear weapons. Nevertheless it is reasonable to conclude that the political and institutional steps the world has taken to prevent proliferation – the creation of the IAEA, the formulation of the IAEA safeguards system, the NPT and the Tlatelolco Treaty[4] – have also played a useful part. They have provided the means for governments to ratify in a binding manner and for all the world to see their decisions to forgo nuclear weapons and also, by accepting IAEA safeguards, to show the world that they are carrying out their undertakings. This assurance to the international community has raised confidence, increased international security and lessened the incentive of other countries to acquire nuclear weapons.

The present safeguards situation

By December 1980 a total of 113 States, including three nuclear-weapon States (USSR, UK, USA), had become parties to the NPT.[5] The NPT covered almost all the non-nuclear-weapon States of the industrial world[6] as well as some 70 developing States (see Fig.2).

---

[3] Although certain processes in the nuclear fuel cycle (enrichment and reprocessing) can be used either for peaceful purposes or to make nuclear explosives, this short summary shows that the *expansion of nuclear power has not gone hand in hand with the spread of nuclear weapons.* Indeed, most of the five nuclear-weapon States tested their first bombs several years before the entry into service of their first power reactors; in one case (China) there is still no nuclear power plant in operation or even under construction.

[4] The conclusion of an effective 'comprehensive test ban treaty', prohibiting all tests of nuclear explosives, would clearly be a further major step in preventing the spread of nuclear weapons. The 1963 Moscow Partial Test-Ban Treaty prohibits such tests in the atmosphere, outer space and under water but does not proscribe underground tests provided that the resulting debris does not cross the frontiers of the testing State. Underground testing by the nuclear-weapon States continues at the rate of about 50 tests a year.

[5] Egypt became party to the NPT on 26 February 1981.

[6] The only industrial non-nuclear-weapon State which has not yet accepted the NPT is Spain, but in March 1981 that country concluded an agreement with the IAEA which had the effect of bringing all existing nuclear activities in Spain under the IAEA's safeguards. This agreement entered into force on 11 May 1981.

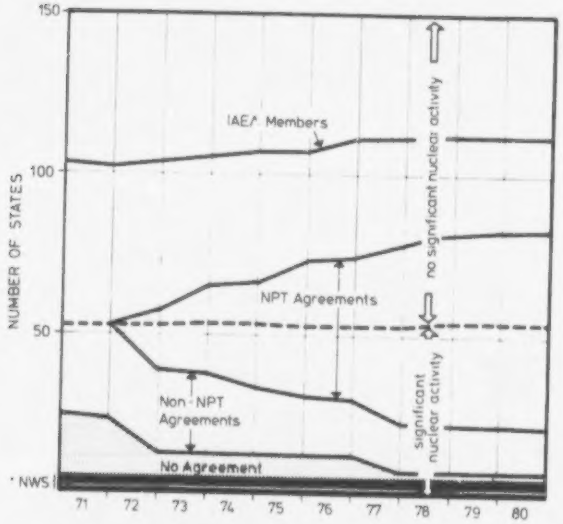

FIG.2. Evolution of safeguards agreements 1970–1980. (**Note:** *Three of the five nuclear-weapon States (NWS) are parties to the NPT).*

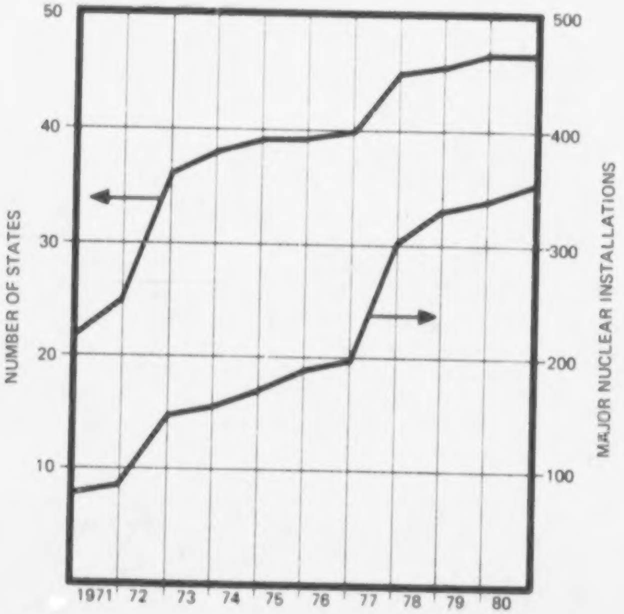

FIG.3. Number of States visited by IAEA inspectors and number of major nuclear installations under safeguards.

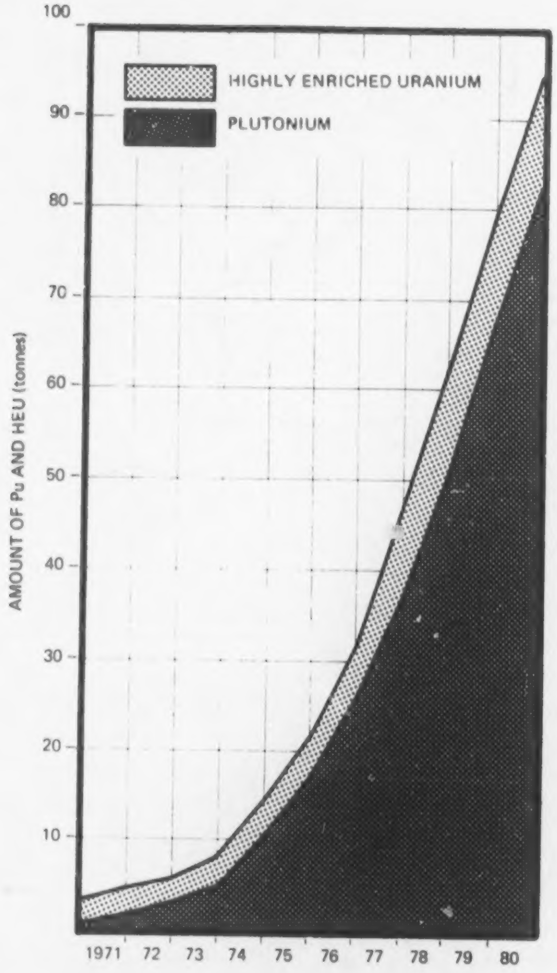

FIG.4. Amounts of plutonium and highly enriched uranium under safeguards.

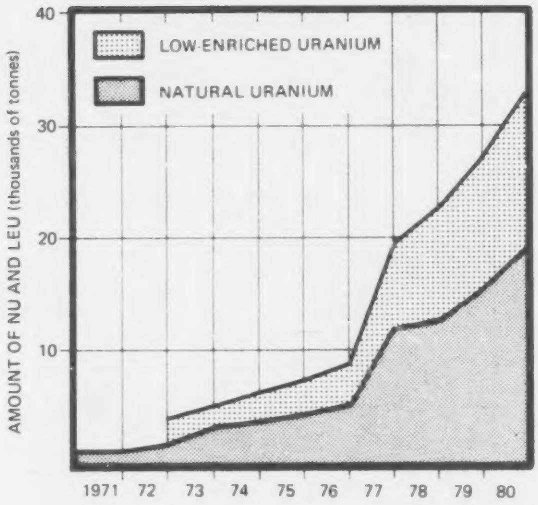

FIG.5. Amounts of natural uranium and low-enriched uranium under safeguards.

By the end of 1980 the IAEA was also applying safeguards in ten non-nuclear-weapon States which were not parties to the NPT, namely Argentina, Brazil, Chile, Colombia, the People's Democratic Republic of Korea, India, Israel, Pakistan, South Africa and Spain. In six of these countries all significant nuclear activities of which the IAEA was aware were covered by a series of individual safeguards agreements. In the remaining four (India, Israel, Pakistan and South Africa), unsafeguarded as well as safeguarded nuclear facilities were in operation or under construction and the unsafeguarded facilities were or will be capable of producing weapons-grade nuclear material.

With the four exceptions noted, almost the entire known nuclear industry outside the nuclear-weapon States is thus under the safeguards of the IAEA.[6] The growth which this has brought to the Agency's safeguards responsibilities is illustrated in Fig.3.

Figure 4 shows the growing amount of highly enriched uranium and of plutonium under IAEA safeguards. Most of the plutonium is in spent fuel from power reactors and would be usable for power production, or as an explosive, only after the fuel had been reprocessed. Figure 5 illustrates the increasing amount of low-enriched and natural uranium under safeguards.

THE OBJECTIVES OF SAFEGUARDS

The political objectives

Safeguards are essentially a technical means of verifying the fulfilment of political obligations undertaken by States in concluding international agreements relating to the peaceful uses of nuclear energy. Today most of these obligations flow from the NPT and similar agreements.

The main political objectives of safeguards are:

> *To assure* the international community that States are complying with their non-proliferation and other 'peaceful use' undertakings;
>
> *To deter* (a) the diversion of safeguarded nuclear materials to the production of nuclear explosives or for other military purposes and (b) the misuse of safeguarded facilities with the aim of producing unsafeguarded nuclear material.

The assurance given by safeguards

States conclude safeguards agreements voluntarily and the IAEA has no authority to apply safeguards unless the State concerned so requests (as it is obliged to do if it is a party to such legal instruments as the NPT). In view of the voluntary nature of this acceptance of safeguards, and for other reasons, it is reasonable to expect that the normal results of applying safeguards will be to confirm that there has in fact not been any diversion. Confirmation that this is so results from independent verification by the IAEA inspectorate. The assurance thus obtained from the IAEA's activities as an independent and objective auditor increases confidence between States and helps to diminish political insecurity which is normally the main motivation for acquiring nuclear weapons.

The deterrent effect

Deterrence is aimed at dissuading any State that might contemplate diversion of nuclear materials or the misuse of nuclear facilities. It follows that, to constitute an effective deterrent, safeguards must be technically capable (and be *seen* to be capable) of promptly detecting the diversion. Detection of diversion must also be seen to entail effective penalties for the diverting country.

Penalties or sanctions

The IAEA Statute and safeguards agreements specify a number of formal sanctions against the breach of a safeguards agreement. They consist chiefly of an alert to the international community (the UN Security Council, the UN General Assembly, all IAEA members), curtailment of IAEA assistance, and suspension of the privileges and rights of IAEA membership.

The effectiveness of these formal sanctions, should it be necessary to evoke them, will depend upon the actions taken by governments in response to the alert given by the Agency. In other words, for safeguards to be an effective deterrent it must be perceived that the international community will respond promptly and vigorously if the IAEA should ever have to 'sound the alarm'.

The extent to which the risk of detection and its consequent penalties would in practice be an effective deterrent will also obviously vary between States and according to political circumstances.

The technical instrument

The technical instrument for achieving the political objectives defined above is the safeguards arm of the IAEA, particularly the Safeguards Department. This is designed to provide continuing assurance to the international community that any diversion would be promptly detected. At least equally important is that it should also provide assurance that if, as has up to now always been the case, no diversion has occurred, the IAEA will be able to verify the correctness of the statements it has received from the State concerning its safeguarded nuclear material and facilities. The political value as well as the effectiveness of the IAEA's safeguards work thus depends significantly on the way in which its detection capability is perceived by those States which expect the IAEA to provide assurance as well as by any State which might contemplate diversion and wished to know how much risk there is of being detected.

Limits to the system

It should be clear that no international safeguards system can physically prevent diversion. The IAEA could not of course prevent any NPT party from exercising its legal right to withdraw from the NPT[7] nor could it prevent countries that have not accepted NPT or similar obligations from building unsafeguarded facilities.[8] Unfortunate as this may be, the IAEA's system can do no more than detect diversion of safeguarded material or misuse of safeguarded plant, and trigger international action. This can, however, be seen as progress since the acceptance of safeguards always involves for the State concerned giving up a measure of national sovereignty.

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[7] For many reasons, withdrawal from the NPT is nevertheless very unlikely. There is no provision for withdrawal from the Tlatelolco Treaty but States may under certain circumstances cease to be bound by certain crucial articles.

[8] Hence there can be no question of the IAEA 'imposing' its safeguards on a reluctant State. The question is sometimes asked: Why doesn't the IAEA step in and place a particular facility under its safeguards? Such action is neither politically nor legally feasible.

Safeguards and physical protection

The protection of nuclear materials and facilities against forcible seizure, theft, terrorism and other criminal activities is the responsibility of the State.[9] This is not the objective of international safeguards, which are directed against the risks of proliferation (or other proscribed activities) *by States*. It follows that the authority and measures required for each of these two activities are different, so too are their objectives and the criteria they apply.

Thus, at the international level the Agency's rights are limited to those which are accorded by the agreement with the State concerned.

A State, on the other hand, is able to use all the power and authority at its disposal, including police and military force, to physically protect nuclear facilities and material and to recover any material which may have been illegally diverted. Similarly, whereas the State may apply the full force of the law to ensure compliance with its legal requirements, the actions that the IAEA may take are explicitly limited by the relevant safeguards agreements and its statute.

The technical objective

The technical objective of safeguards in agreements concluded under the NPT is defined as "the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or other nuclear explosive devices or for purposes unknown and deterrence of such diversion by risk of early detection". In safeguards agreements concluded under the non-NPT system (INFCIRC/66 Rev.2) there is no specific definition of technical objectives but in practice today essentially the same concepts apply.

This definition contains two expressions requiring quantification: 'significant quantities' of nuclear material and 'timely detection' of diversion.

It is again important to keep in mind the difference in the content of these terms when they are used in relation to national measures of physical protection and when used with international safeguards.

A national physical protection system may have to be designed to detect unlawful action within hours or even minutes. Moreover the unlawful removal or other misuse of only a few grams of plutonium could be significant because of the health hazard it may pose.

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[9] In some countries *physical* protection measures are also referred to as safeguards.

Since the objective of an international safeguards system is essentially to deter governments from making nuclear weapons or other nuclear explosives, the detection within hours or even minutes of such small amounts as a few grams is not necessary and cannot reasonably be required. For international safeguards the significant quantity is the approximate quantity of nuclear material which could possibly be used to manufacture a nuclear explosive device. It is of the order of magnitude of 8 kilograms of plutonium or 25 kilograms of highly enriched uranium.

Similarly, in the context of international safeguards 'timely detection' can be related to the time required to convert diverted material into the components of a nuclear explosive device (namely, conversion time).

Results so far

As has been said, safeguards can exercise their deterrent effect only if they are seen to be capable of early detection of a diversion. IAEA safeguards have been applied since the 1960s. No diversion of any safeguarded item has been recorded, and while the possibility of a future diversion of safeguarded material or misuse of plants cannot be excluded its likelihood will generally remain small, partly because of the operation of the system itself. While the effectiveness of a national police force can be measured in terms of its success rate against crime, that of international safeguards cannot be demonstrated by statistics showing for instance the proportion of diversions detected in relation to the total number of diversions. Other means must be used in order to give an assurance of this kind to the Agency's Member States that the IAEA safeguards system is effective.

Thus, for instance, governments are informed not only of the conclusions the IAEA reaches in implementing safeguards but also of the rationale and methods used to reach these conclusions, the approaches and procedures followed in applying safeguards and the factual material on which the conclusions are based.

To give an example: in 1980 about six million 'surveillance' pictures were taken in nuclear facilities and evaluated by the IAEA, 6000 seals were issued, and 3000 were returned for verification. IAEA inspectors and safeguarded States submitted reports on about 700 nuclear installations, and about 400 000 data entries were made in the Agency's computer. The effectiveness of inspection and evaluation activities in disclosing departures from the norm is shown by the fact that in 1980 about 200 discrepancies and anomalies were detected. Most of them were minor and in all cases they were satisfactorily explained upon subsequent appraisal and investigation. It was thus again reasonable to conclude that nuclear material under IAEA safeguards in 1980 – as in previous years – had remained in peaceful nuclear activities or had otherwise been adequately accounted for.

SAFEGUARDS APPROACHES AND IMPLEMENTATION

The State's system of accounting for and control of nuclear materials (SSAC)

Safeguards agreements concluded pursuant to the NPT require the State to establish and maintain a national system of accounting for and control of nuclear material within its territory, jurisdiction or control (in the case of the European community the safeguards system of Euratom fulfils this function). In fact, most States having a significant nuclear programme, whether or not they are parties to NPT safeguards agreements with the IAEA, find it to be in their national interest to establish effective means of accounting for and control of nuclear materials in their territories.

The safeguards measures applied by the IAEA will now be described in more detail. In NPT States (and increasingly in others as well), the IAEA nuclear materials accountancy and verification are based on *reports* submitted by the SSAC as well as on *records* kept at facilities. It is the responsibility of the competent national authority to ensure that plant operators comply with the requirements of the safeguards agreement. These requirements include proper and accurate keeping of records and timely and accurate reporting according to an agreed format. The national authority must also ensure that the capabilities and equipment at nuclear factilities for measuring the quantity and composition of nuclear material are maintained at the level of the latest international or comparable standards. The national authorities are also responsible for ensuring that IAEA inspectors are granted all necessary access to facilities and material and for providing the support they require effectively to discharge their duties. They must also enable and assist IAEA inspectors to apply containment and surveillance measures (e.g. seals, cameras, and other recording devices) at nuclear facilities. In some cases the same measure or device is used to meet the requirements of both domestic physical protection measures and IAEA safeguards.

Design of the safeguards approach

The material for nuclear explosives, whether highly enriched uranium (HEU) or plutonium (Pu), is produced in specialized facilities. The construction and misuse of commercial nuclear power reactors is not the easiest nor the most efficient route to acquiring nuclear material for the manufacture of nuclear explosives. However, fuel cycle facilities associated with such reactors might be used in some circumstances to produce unsafeguarded nuclear material for nuclear explosives. It is, therefore, necessary for *all* nuclear material in a country's fuel cycle to be safeguarded if the IAEA is to be in a position to give assurances of non-diversion for the State as a whole.

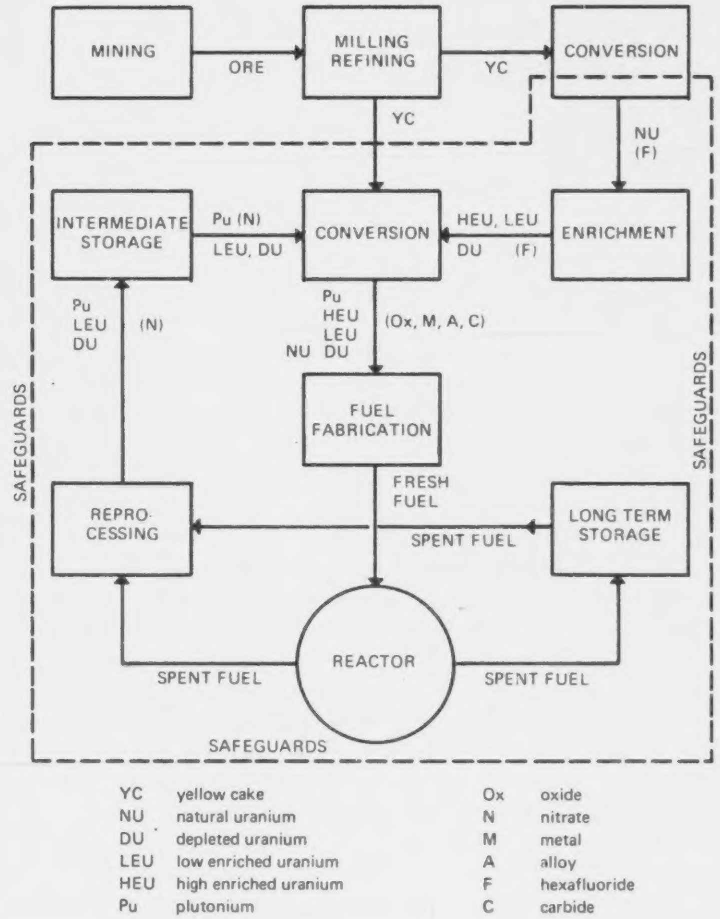
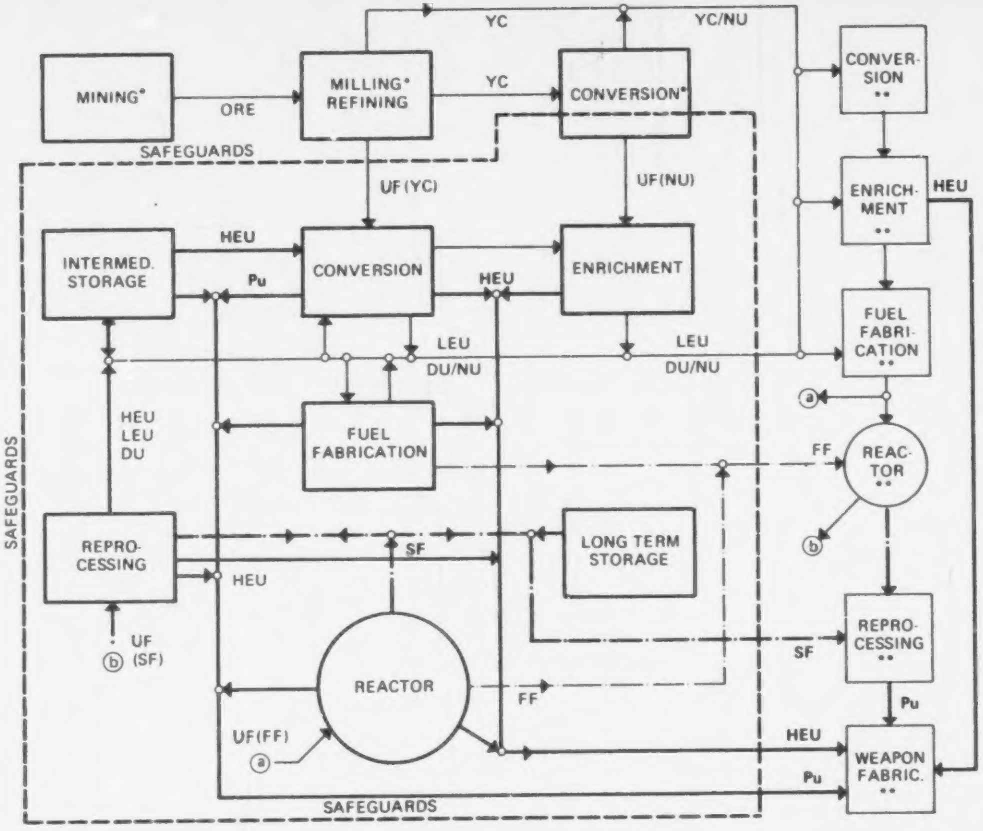

MINING
ORE
MILLING REFINING
YC
CONVERSION
YC
NU (F)
INTERMEDIATE STORAGE
Pu (N)
LEU, DU
CONVERSION
HEU, LEU
DU (F)
ENRICHMENT
Pu LEU DU
(N)
Pu HEU LEU DU
NU
(Ox, M, A, C)
FUEL FABRICATION
FRESH FUEL
SAFEGUARDS
SAFEGUARDS
REPRO-CESSING
SPENT FUEL
LONG TERM STORAGE
REACTOR
SPENT FUEL
SPENT FUEL
SAFEGUARDS
YC yellow cake
NU natural uranium
DU depleted uranium
LEU low enriched uranium
HEU high enriched uranium
Pu plutonium
Ox oxide
N nitrate
M metal
A alloy
F hexafluoride
C carbide

FIG.6. Simplified flow diagram of the nuclear fuel cycle.

The term 'nuclear fuel cycle' refers to the system of nuclear installations interconnected by a stream of nuclear material used in the production of nuclear energy.

Such a system may consist of uranium mines, ore-processing plants, conversion plants, enrichment plants, fuel fabrication plants, reactors (where the energy is extracted), spent fuel storages, reprocessing plants and associated storage. The fuel cycle can be 'closed' in various ways, e.g. by recycling of plutonium and uranium through reactors, by re-enriching the uranium recovered as a result of reprocessing, or by using the plutonium in the fast breeder reactor fuel cycle. All these stages taken together are illustrated schematically in Fig.6.


MINING*
ORE
MILLING* REFINING
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YC
YC/NU
CONVERSION*
SAFEGUARDS
UF(YC)
UF(NU)
INTERMED. STORAGE
HEU
Pu
CONVERSION
HEU
ENRICHMENT
LEU
DU/NU
LEU
DU/NU
HEU
LEU
DU
FUEL FABRICATION
REPRO-CESSING
SF
HEU
LONG TERM STORAGE
UF
ⓑ (SF)
REACTOR
FF
UF(FF)
ⓐ
SAFEGUARDS
SAFEGUARDS
CONVER-SION **
ENRICH-MENT **
HEU
FUEL FABRI-CATION **
ⓐ
FF
REAC-TOR **
ⓑ
SF
REPRO-CESSING **
Pu
HEU
Pu
WEAPON FABRIC. **

YC	yellow cake
NU	natural uranium
LEU	low enriched uranium
HEU	high enriched uranium
Pu	plutonium
DU	depleted uranium
FF	fresh fuel
SF	spent fuel
UF	undeclared fuel

* These facilities are normally not under safeguards.

** These facilities might exist as undeclared facilities under a full scope agreement.

FIG.7. Simplified flow diagram of proliferation paths.

Of course, only a few countries have facilities corresponding to all the installations shown in the figure. In most countries only part of the fuel cycle exists – in the minimum case only a power reactor supplied from abroad, or an R & D laboratory.[10]

An important step in the analytical process leading to adoption of a specific safeguards approach is a careful analysis of hypothetical 'diversion strategies' that could be used by a diverter. Figure 7, in contrast to Fig.6, does not show the legitimate paths normally followed by nuclear material in a commercial fuel cycle, but surveys the diversion paths along which nuclear material could be diverted. The possibility of unsafeguarded facilities[11] must be assumed in any safeguards study and this is also reflected in Fig.7, which shows the confusing variety of 'diversion paths' for different kinds of nuclear material that have to be analysed. This diagrammatical representation must of course be extended or simplified in each individual case to reflect the actual fuel cycle of the country concerned. The set of diversion paths which is assumed to be part of plausible diversion strategies forms the 'diversion assumption' and is taken into account in designing, implementing and evaluating safeguards in a given situation.

Safeguards practices can be summarized in one word: verification. To verify means 'to establish the truth of'. In safeguards, to verify is to establish the truth of statements regarding the amounts, presence and use of nuclear material or other items subject to safeguards as recorded by facility operators and as reported by the State to the IAEA. Accountancy, taken together with containment and surveillance, is the fundamental basis on which verification rests.

The verification process can be described as consisting of three distinct stages:

(1) The *examination* of the information provided by the *State* in:
  - Design information describing installations under safeguards
  - Accounting reports listing, inter alia, nuclear material inventories, receipts and shipments
  - Documents amplifying and clarifying reports
  - Advance notification of international transfers.

(2) The *collection* of information by the *IAEA* as a result of:
  - Inspections for the verification of the design information
  - Inspections to examine records and reports and inspection of nuclear material
  - Special inspections in case of unusual findings.

---

[10] A more detailed description of the fuel cycle facilities can be found in the IAEA publication 'IAEA Safeguards: Glossary' (IAEA/SG/INF/1, published 1980).

[11] The existence of such facilities may or may not be acknowledged. In the case of NPT States such facilities would of necessity be 'undeclared', i.e. clandestine.

(3) The *evaluation* of the information provided by the State and of that collected by inspectors, to determine the completeness, accuracy and validity of the information provided by the State.

Statements are provided by the IAEA to States, recording the results of safeguards activities in the State concerned. Mechanisms are in existence for the resolution of anomalies and discrepancies which may be detected by the IAEA.

Nuclear materials accountancy [12], [13]

It is the purpose of nuclear materials accounting[13] to establish the quantities of nuclear material present within defined areas and the changes in these quantities that take place within defined periods of time. The essential elements of such accounting are:

The operator identifies and counts or measures the material in the area concerned

The operator keeps records of all transactions involving this material

The operator prepares accounting reports on these transactions and submits these reports via the State to the IAEA

The IAEA verifies and analyses the data in these reports to determine their correctness and to assess the amount of any material unaccounted for and evaluate the causes of any such material unaccounted for.

To make these tasks more manageable, material balance areas (MBAs) are established in nuclear installations. These MBAs are areas into and out of which all transfers can be determined and in which physical inventories can be taken to establish a nuclear material balance. The MBAs are agreed between States and the IAEA and are recorded in Subsidiary Arrangements to the Safeguards Agreements which regulate in detail the implementation of safeguards agreements. Within MBAs measurements are made at key measurement points (KMPs), which are locations where nuclear material may be measured for the determination of flow or inventory.

Accountancy in IAEA terms begins in practice with the determination by the operator of the *initial physical inventory* (stock-taking) for a facility or MBA and the recording of that inventory in a book in which the operator thereafter records subsequent *inventory changes*. The results of periodical *physical inventory takings* by the operator and their relation to corresponding book inventories are fundamental to nuclear material accountancy. Any difference between the book inventory and the physical inventory is called 'material unaccounted for', abbreviated to MUF. The reasons for MUF may be found in measurement uncertainties or other technical causes. If the size of the MUF is found to be beyond a value attributable to such identifiable causes, the possibility that a diversion has been made must be considered.

---

[12] The explanations in this sub-section apply to the majority of Agency safeguards agreements, which are concluded in accordance with the NPT, and to some extent with other agreements as well.

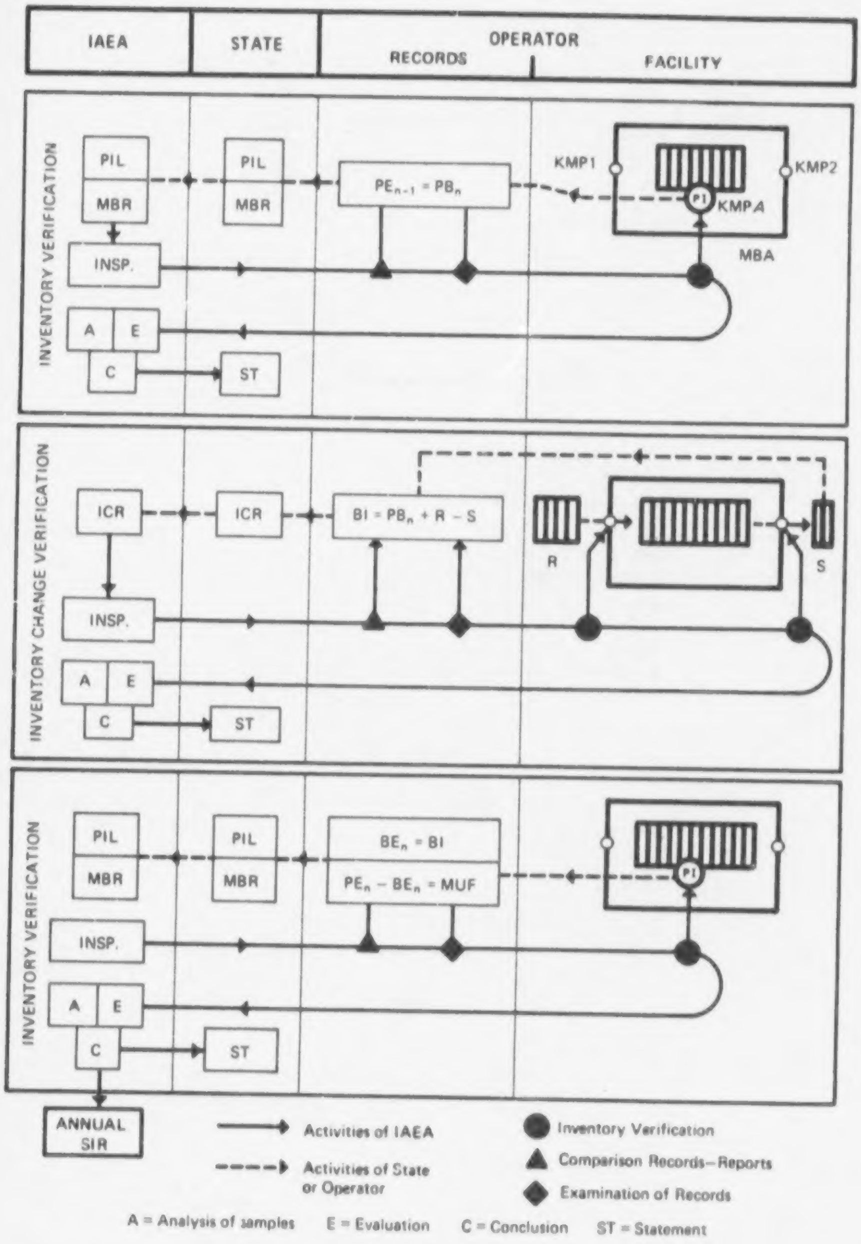
[13] In safeguards a certain distinction is made in the meaning of the words accountancy and accounting (see the definitions in 'IAEA Safeguards: Glossary' (IAEA/SG/INF/1, p.28).

Figure 8 is a highly simplified view of the application of accountancy procedures. When closing the books in respect of a material balance period (e.g. the calendar year n–1) in an MBA, the operator takes a physical inventory (PI) at the prescribed KMPs of all nuclear material present in the MBA, by counting, identifying, weighing, etc. The resulting figures for this 'beginning inventory' (PB_n) are at the same time the ending physical inventory (PE_{n-1}) for the previous material balance period, and the beginning book inventory for the next material balance period (see top block in Fig.8). The operator reports the results to the responsible State Office in the form of a physical inventory listing (PIL) and a material balance report (MBR) for the material balance period which closed. These reports are then transmitted to the IAEA. At the same time as the physical inventory takes place, or shortly thereafter, an IAEA inspection of the facility takes place for the purpose of verifying the physical inventory taking by making independent measurements, taking samples, etc. The results of this inspection and of the analysis of any samples are evaluated and the conclusions reached by the IAEA are transmitted to the State in the form of a statement (ST).

We now turn to the middle block in Fig.8. Any changes in the balance of nuclear material (e.g. receipts (R), shipments (S) or discards) are entered by the operator in his records and up-date his book inventory (BI). The changes are also reported through the State Office to the IAEA in the form of inventory change reports (ICRs). Routine IAEA inspections may be carried out to verify these changes, and the records are examined and compared with the reports sent to the IAEA. The results of these inspections are evaluated and the conclusions reached are communicated to the State.

The material balance period is closed by activities schematically represented in the last block in Fig.8. After verification of the ending physical inventory (PE_n) the difference (MUF) between the book inventory (BE_n) and the physical inventory (PE_n) is determined and evaluated and a statement is formulated. Once each year the IAEA submits a safeguards implementation report (SIR) to the Board of Governors. The SIR contains an overall assessment of safeguards effectiveness during the previous year and an analysis of the effectiveness and efficiency of safeguards implementation.

In his independent verification activities the inspector uses several methods which have been mentioned already in general terms. Figure 9 shows a simplified description of such methods used, inter alia, in a nuclear power reactor. A power


IAEA
STATE
OPERATOR
RECORDS
FACILITY
INVENTORY VERIFICATION
PIL
MBR
PIL
MBR
$PE_{n-1} = PB_n$
KMP1
KMP2
PI
KMP A
MBA
INSP.
A
E
C
ST
INVENTORY CHANGE VERIFICATION
ICR
ICR
$BI = PB_n + R - S$
R
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INSP.
A
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C
ST
INVENTORY VERIFICATION
PIL
MBR
PIL
MBR
$BE_n = BI$
$PE_n - BE_n = MUF$
PI
INSP.
A
E
C
ST
ANNUAL SIR
Activities of IAEA
Activities of State or Operator
Inventory Verification
Comparison Records–Reports
Examination of Records
A = Analysis of samples
E = Evaluation
C = Conclusion
ST = Statement

FIG.8. Simplified scheme of nuclear material accountancy (explanation in the text). A – Analysis of samples. E – Evaluation. C – Conclusion. ST – Statement.

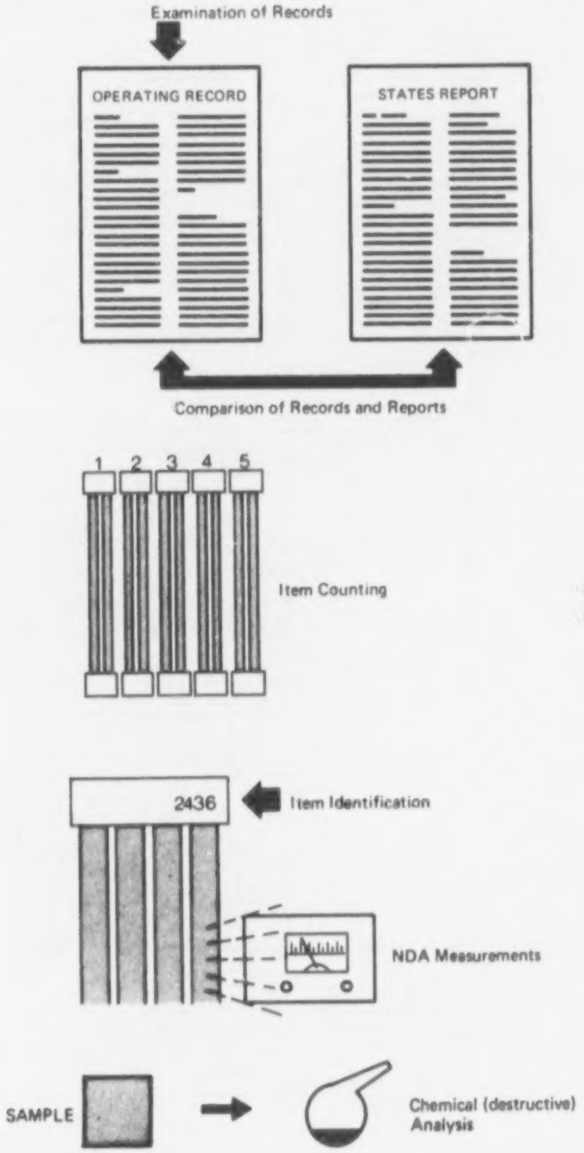

Examination of Records
OPERATING RECORD
STATES REPORT
Comparison of Records and Reports
1
2
3
4
5
Item Counting
2436
Item Identification
NDA Measurements
SAMPLE
Chemical (destructive) Analysis

FIG.9. Verification activities of inspectors or of the Safeguards Analytical Laboratory. (NDA = non-destructive assay).

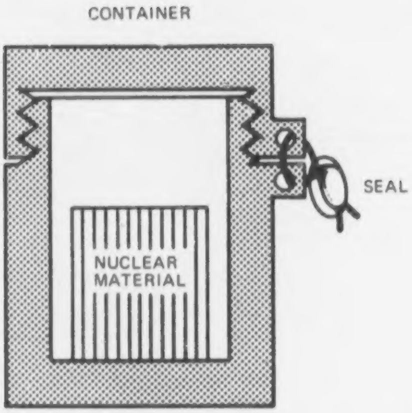


FIG.10. Containment measures: application of seal.

reactor is an 'item facility', i.e. the nuclear fuel is contained in identifiable items (fuel assemblies), the integrity of which is usually preserved during their presence in the plant. Such items can be followed through a considerable part of the whole fuel cycle, from the fuel fabrication plant, through the reactor, to the reprocessing plant or long-term storage. This facilitates the task of safeguards. Inspectors count the fuel assemblies, identify them by serial number or seals, and check on a statistical basis the fuel composition by non-destructive measurements. In 'bulk handling facilities', e.g. fuel fabrication plants, samples (pellets, powder, solutions) are taken and destructively analysed in the Agency's Safeguards Analytical Laboratory, by chemical or physical methods.

Containment and surveillance

Containment and surveillance measures take advantage of physical barriers such as walls, containers, tanks or pipes, to restrict or control the movement of or access to nuclear material. Such measures help to reduce the probability that undetected movements of nuclear material or equipment can take place. Containment/surveillance measures may involve the application of devices such as uniquely identified tamper-indicating seals to ensure that any change in the sealed inventory will be detected.

Surveillance means both human and instrumental observation in order to detect undeclared movements of nuclear material, tampering with containment, fabrication of false information or tampering with safeguards devices. Surveillance

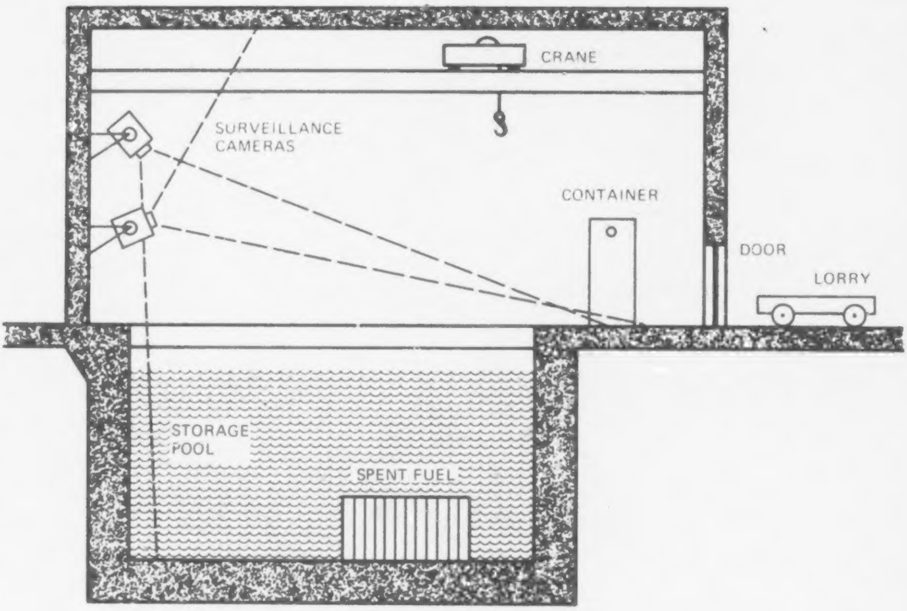


FIG.11. Combined application of containment and surveillance.

may involve the use of tamper-resistant automatic cameras or other devices to monitor changes in containment or to observe inventory changes. Personnel may carry out the same tasks by manning key observation points continuously or periodically.

For example, if a physical inventory of fresh fuel or of a new core loading in a reactor has been taken and it is possible to seal the fuel container (Fig.10) or reactor vessel, it is sufficient to verify periodically that the seal has not been tampered with in order to conclude that the inventory has not changed since the time when the seal was applied or last verified.

In the spent fuel storage, inspectors may make use of a combination of available containment/surveillance measures as shown in Fig.11. In this case, containment is provided by the walls of the building while surveillance is carried out by twin cameras which, during the absence of inspectors, take pictures at intervals shorter than the time needed to remove any fuel. Periodic evaluation of the films would thus reveal any removal of spent fuel.

The IAEA containment/surveillance measures are designed in such a way as to minimize intrusion in the work of a nuclear facility operator.

Inspections

Inspection is essential to implement the safeguards measures described above. Its aim is to verify the validity of information in the possession of the Agency. The maximum intensity and frequency of inspections are specified in the safeguards agreements and vary with the type of facility inspected. A proportion of routine inspections may be unannounced.

The NPT safeguards system distinguishes between three types of inspections.

Routine inspections are made to verify that the information contained in reports submitted by the State is consistent with the accounting and operating records kept by the operator. Routine inspections also verify the amount, the location and the identity of nuclear material, investigate shipper/receiver differences (in other words any differences in reports about the same item which may occur in notifications received from the shipper and the receiver of the item), uncertainties in book inventories, and MUF.

Ad-hoc inspections are made to verify information submitted by States regarding the design of new nuclear facilities, the first report made by the State after the conclusion of the safeguards agreement and changes between the submission of that first report and the beginning of routine inspections. Inspections made to verify material before it is sent abroad or after it is received from abroad are also classified as ad-hoc.

Special inspections are made in addition to routine inspections when unusual circumstances occur and are notified to the Agency in 'special reports', or in order to collect information in addition to that which the State routinely provides or which is obtained by routine inspections but is found to be inadequate. Special procedures must be followed for special inspections.

During inspections the IAEA's inspectors carry out numerous tasks; for instance they:

- Examine pertinent records
- Make independent measurements of safeguarded nuclear material (they may use the IAEA's own equipment or the State's or operators' equipment)
- Verify the proper functioning and calibration of equipment
- Obtain samples and ensure that they are properly collected, tested, handled and shipped
- Use and service IAEA surveillance equipment
- Affix, inspect and remove IAEA seals.

Verification is concentrated on the stages of the fuel cycle that involve the production, processing, use or storage of nuclear materials from which weapons could be readily made. The verification effort must however in all cases be sufficient to enable the IAEA to meet the defined objective of safeguards: the timely detection of the diversion of a significant quantity of nuclear material.

ORGANIZATION OF IAEA SAFEGUARDS

In discharging the safeguards responsibilities of the Secretariat, the Director General is supported by the Department of Safeguards and the Department of Administration. The former department deals with the implementation of safeguards and their development and evaluation; the latter provides assistance in the drafting and negotiating of safeguards agreements and in policy matters. The place of the Department of Safeguards in the framework of the Agency can be seen from Fig.12 and its internal structure from Fig.13.

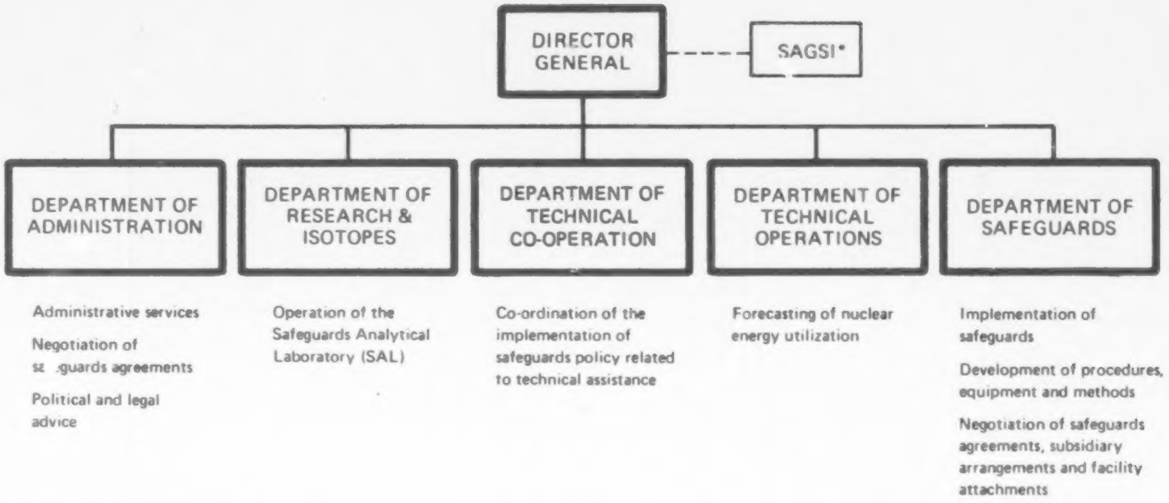
Safeguards operations

The implementation of safeguards agreements is entrusted to the two Divisions of Operations. Each consists of three Regional Sections and is manned by inspectors and supporting staff responsible for the direct application of safeguards. By the end of 1980 there were about 120 inspectors in these two divisions. Each division is responsible for planning inspection programmes and performing inspections. After returning from inspections, inspectors prepare inspection reports which include the data they have collected and the conclusions they have drawn. Inspectors are supported in their work by other units in the Department (e.g. data processing, analytical and evaluation services). The results of inspections and corresponding evaluations are condensed into statements which are sent to the respective States. The Divisions of Operations also up-date design information on facilities under safeguards and participate in the preparation and negotiation of Safeguards Agreements and Subsidiary Arrangements including Facility Attachments[14] needed to implement safeguards agreements. The divisions also do valuable work in summarizing their safeguards experience and participating in the development of new safeguards approaches.

The allocation of countries to the different Regional Sections has been decided upon taking into account the geographical location of each country and the inspection effort required for the facilities in it. The present organizational structure is as shown in Fig.13. The Regional Sections of the Division of Operations A implement safeguards in countries as follows:

---

[14] Subsidiary Arrangements describe interpretations of provisions in the Safeguards Agreement as accorded between the Agency and the State(s), and indicate in detail the manner in which the Agreement is to be implemented. Details of procedures applicable to all facilities in the State are included in the General Part of the Arrangements. Procedures relating to specific facilities are laid down in the Facility Attachments.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SAGSI*
DEPARTMENT OF ADMINISTRATION
DEPARTMENT OF RESEARCH & ISOTOPES
DEPARTMENT OF TECHNICAL CO-OPERATION
DEPARTMENT OF TECHNICAL OPERATIONS
DEPARTMENT OF SAFEGUARDS
Administrative services
Negotiation of safeguards agreements
Political and legal advice
Operation of the Safeguards Analytical Laboratory (SAL)
Co-ordination of the implementation of safeguards policy related to technical assistance
Forecasting of nuclear energy utilization
Implementation of safeguards
Development of procedures, equipment and methods
Negotiation of safeguards agreements, subsidiary arrangements and facility attachments

* Standing Advisory Group on Safeguards Implementation

FIG.12. Organizational structure of the IAEA and the safeguards-oriented activities of its Departments.

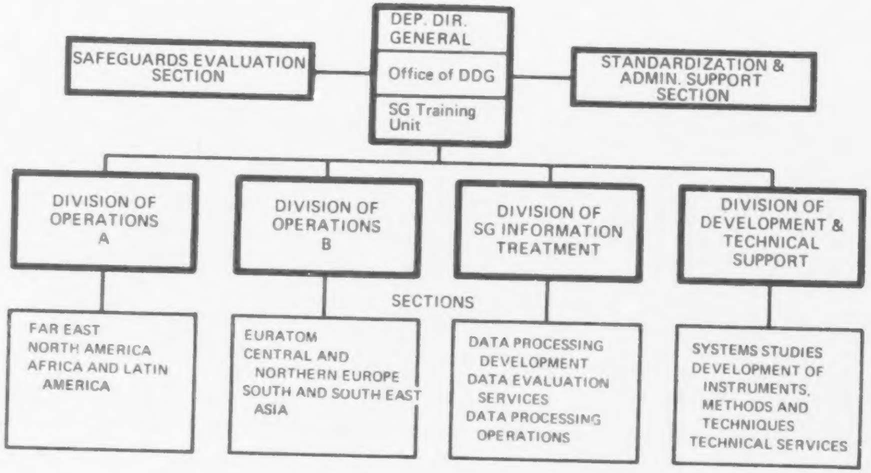
DEP. DIR. GENERAL
Office of DDG
SG Training Unit
SAFEGUARDS EVALUATION SECTION
STANDARDIZATION & ADMIN. SUPPORT SECTION
DIVISION OF OPERATIONS A
DIVISION OF OPERATIONS B
DIVISION OF SG INFORMATION TREATMENT
DIVISION OF DEVELOPMENT & TECHNICAL SUPPORT
SECTIONS
FAR EAST
NORTH AMERICA
AFRICA AND LATIN AMERICA
EURATOM
CENTRAL AND NORTHERN EUROPE
SOUTH AND SOUTH EAST ASIA
DATA PROCESSING DEVELOPMENT
DATA EVALUATION SERVICES
DATA PROCESSING OPERATIONS
SYSTEMS STUDIES
DEVELOPMENT OF INSTRUMENTS, METHODS AND TECHNIQUES
TECHNICAL SERVICES

FIG.13. Organizational structure of the Department of Safeguards.

Far East Section: Japan, Republic of Korea, Taiwan

North America Section: Canada, USA[15]

Africa and Latin America Section: Argentina, Brazil, Chile, Colombia, Libyan Arab Jamahiriya, Mexico, Peru, Portugal, South Africa, Spain, Uruguay, Venezuela, Zaire.

The Regional Sections of the Division of Operations B implement safeguards in countries as follows:

Euratom Section: Belgium, Denmark, France[16], Federal Republic of Germany, Ireland, Italy, Luxembourg, Netherlands, United Kingdom[16].

Central and Northern Europe Section: Austria, Bulgaria, Czechoslovakia, Finland, German Democratic Republic, Hungary, Norway, Poland, Romania, Sweden, Switzerland

South and South East Asia Section: Australia, Democratic People's Republic of Korea, Greece, India, Indonesia, Iran, Iraq, Israel, Pakistan, Philippines, Thailand, Turkey, Yugoslavia.

The workload of inspections and accordingly the manpower and financial requirements-depend in the first instance on the number and type of installations under safeguards or containing safeguarded material. The growth of this number depends on the one hand on the development of nuclear energy throughout the world, on the other hand on the increase in numbers of safeguards agreements. Figure 14 shows the growth in the number of reactors under safeguards. The number of research reactors remained rather stable during the last decade and the increase shown in Fig.14 was mainly due to the increasing number of safeguards agreements. The growth curve of power reactors however reflects also a real increase of power reactors actually in operation. All nuclear power reactors in all non-nuclear-weapon States are now under safeguards (see Footnote 6).

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[15] The agreement between the USA and the IAEA for the application of safeguards in the United States will be implemented in 1981. Under this agreement the USA permits the IAEA to apply its safeguards to all nuclear activities in the USA, "excluding only those with direct national security significance." The IAEA designates the facilities in which it will apply safeguards. Until now the IAEA has applied safeguards in the USA when so required by agreements with third countries, as well as in the USA or under special limited arrangements.

[16] The UK has similarly offered to accept safeguards on all facilities in the UK, "subject to exclusions for national security reasons only", and the relevant agreement entered into force in 1978. This agreement will likewise be implemented in 1981 at facilities designated by the IAEA. France has negotiated an agreement with the IAEA which will permit the IAEA to apply safeguards at facilities listed by France; this agreement entered into force on 12 September 1981. Until now, the IAEA has been applying safeguards in the UK and in France only in cases when so required by agreements involving third countries or under special arrangements.

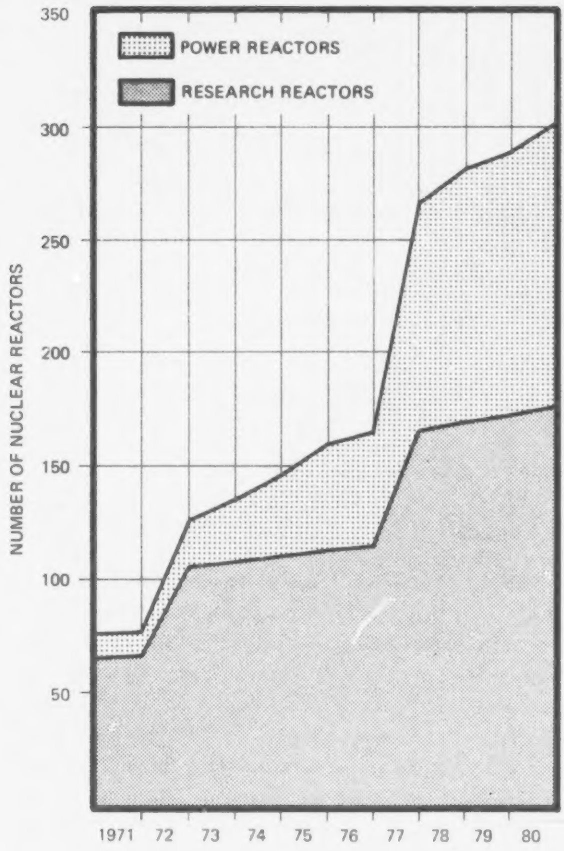

FIG.14. Number of nuclear reactors under safeguards.

As already mentioned, reactors are item facilities whose readily identifiable items (fuel assemblies) facilitate accounting for the contained nuclear material. The inspection effort needed to attain the safeguards objective depends on the type of reactor and lies between 1 and 50 man-days per year and reactor. For the light water reactors, which are by far the most common type of power reactor, about 10 – 15 inspector man-days per year are necessary.

Figure 15 shows the increase in the number of safeguarded bulk handling facilities in which nuclear material is handled in loose form (conversion plants, fuel fabrication plants, reprocessing plants, enrichment plants). Safeguarding such plants may require the presence of inspectors at frequencies ranging from 20 man-days per year up to continuous presence at the installation, depending on size and type of plant.

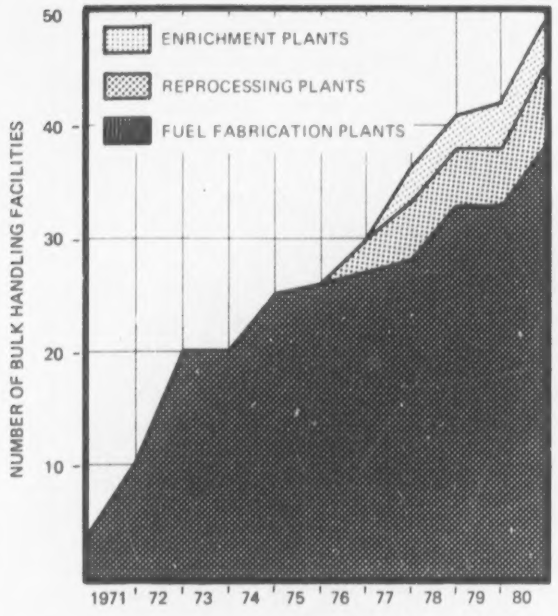

FIG.15. Number of bulk handling facilities under safeguards.

Besides the major types of facilities mentioned above several other installations like separate storage, other facilities and other locations outside facilities (for instance small research laboratories) have also been safeguarded (Fig.16).

The number of large installations under safeguards increased more than 4 times between 1970 and 1980 but, because of the growing unit size of installations and the increasing amount of spent fuel, the quantity of nuclear material under safeguards rose even more rapidly. During the same period the professional staff of the Department of Safeguards increased by a factor of only about 2.5. In 1980 about 1100 inspections were made at more than 500 facilities in 47 States.

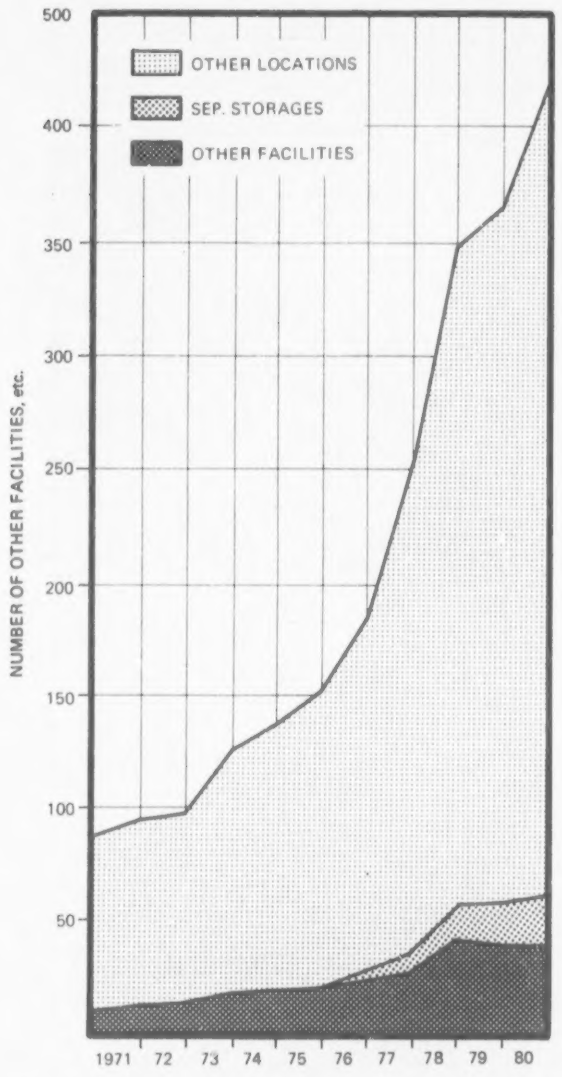

FIG.16. Number of separate storage facilities, other facilities and other locations under safeguards.

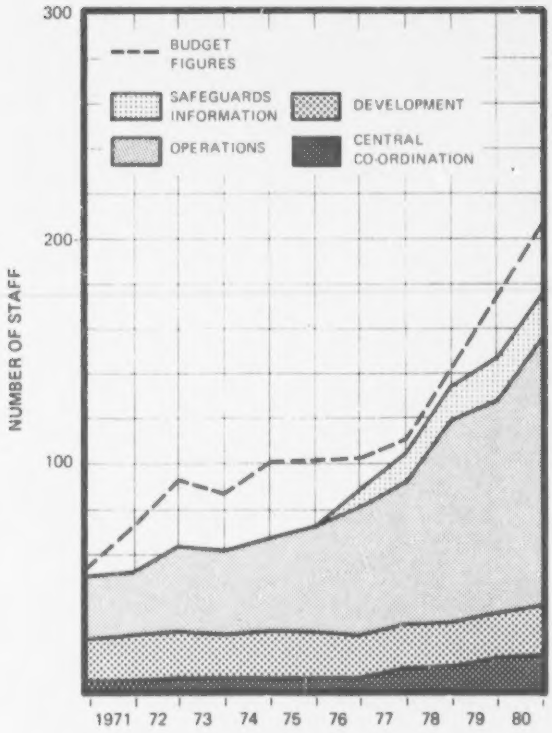

FIG.17. Increase in number of professional staff in the Department of Safeguards.

The growing safeguards workload obviously requires an increase in manpower of the IAEA inspectorate (Fig.17). The Agency recruits its personnel on as wide a geographical basis as possible. This enhances the credibility of the safeguards system in that it enables the Agency to avoid sending inspectors to their own country.

It is not always easy to recruit the qualified manpower, however. By the end of 1980 the inspectors of the Divisions of Operations came from 39 countries, including 26 developing countries.

Information treatment

Safeguards operations are supported by other organizational units, amongst them the Division of Safeguards Information Treatment (see Fig.13), handling the vast amount of safeguards information reported by States and collected by inspectors. The Division comprises three Sections.

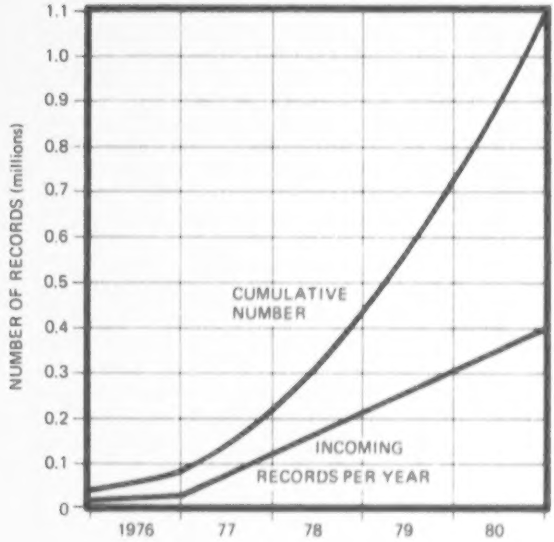

FIG.18. Increase in workload of the Division of Safeguards Information Treatment.

The *Data Processing Operations Section* is responsible for the computer processing of a variety of safeguards information including the accounting data furnished by Member States, inspection data and design data. The *Data Evaluation Services Section* provides assistance to inspectors in preparing inspections, evaluating their results, preparing inspection reports, evaluating data quality and trends, correlating data and analysing statistics. The *Data Processing Development Section* is responsible for the continuing development and evaluation of the computer techniques needed to satisfy the growing safeguards requirements.

The increasing number of records and reports which the Division of Safeguards Information Treatment processes and evaluates each year is shown in Fig.18. Several thousand questions are put to the system each year to satisfy the needs of the Divisions of Operations. Computer output data are also included in the annual Safeguards Implementation Report. Direct access to computerized data is permitted only to authorized safeguards personnel. This access is arranged by the use of computer terminals which provide immediate information on a 'need-to-know' basis. The arrangements for data stored in the computer are carefully designed to ensure their security. Established procedures are continually evaluated for their effectiveness.

Development and technical support

The Divisions of Operations require not only the support of an efficient computer unit; their activities in the field must be based on sophisticated safeguards strategies and techniques, their inspectors must be intensively trained, and they must be supplied with equipment of the highest possible standard. The resulting widely diversified tasks are assigned to the Division of Development and Technical Support (see Fig.13). There are three Sections in this Division.

The *Systems Studies Section* is the think tank of the Department. For each type of facility, plausible diversion strategies have to be postulated and safeguards approaches to defeat them have to be developed, together with methods for determining the effectiveness of the approaches.

Safeguards could not be efficiently and effectively implemented without large-scale use of all sorts of equipment and instrumentation for measurements, analyses and surveillance. This equipment must not only be accurate but also rugged, simple and portable. The main responsibility for developing, acquiring and testing the necessary equipment and instrumentation lies with the *Section for Development of Instruments, Methods and Techniques.* The IAEA does not have the financial resources to operate a special research and development laboratory and is therefore dependent on the support of Member States. At present three Member States[17] are funding research and development projects in safeguards problem areas suggested by the IAEA or in areas where existing equipment or instrumentation needs improvement or greater sophistication or flexibility. The Development Section defines the problems or specifications, co-ordinates the international efforts and performs acceptance tests.

The *Technical Services Section* is responsible for the provision of equipment, instruments and seals. This includes procurement, storage, calibration, maintenance, shipment and instruction on the use of instruments and in the application of techniques. Samples for analysis, taken by the inspector, are received by the Section and shipped for analysis to the Safeguards Analytical Laboratory, Seibersdorf, or a laboratory of the International Network of Analytical Laboratories. Seals are at present issued at the rate of 6000 a year. Optical surveillance devices such as film cameras are used in locations such as spent fuel storage ponds where sealing is impractical. More than one hundred twin-camera units are taking photos at a rate of over 20 000 per day.

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[17] Canada, Federal Republic of Germany, USA. Projects with Australia, Japan, USSR, UK and Euratom are under preparation.

Conclusion

The safeguards component in the Agency's budget increased from 10% in 1970 to 27% in 1980, reflecting the growth of the peaceful uses of nuclear energy and the increase in nuclear material and installations to be safeguarded. The major part of the budget is allocated to the promotional activities of the Agency. The cost of safeguards, which is at present borne largely by developed States, is appreciable, but in perspective it is not large – of the order of the cost of a single military aircraft per year. Divided by the energy produced by nuclear reactors annually throughout the world, it represents a cost of approximately US $0.00003 per kWh of electricity. Even if one applies a factor to this figure to include the safeguards expenses incurred by States and plant operators, the resulting cost is still minor compared with the benefits derived – a considerable contribution to international security.

Until now, safeguards have been invoked only to verify agreements dealing with nuclear energy. There is no technical reason, however, why the concept of safeguards should not extend to other international agreements dealing with potentially hazardous materials and equipment, for instance in the field of arms control and disarmament.

BIBLIOGRAPHY

The Agency's Statute	
The Non-Proliferation Treaty	IAEA Document INFCIRC/140
The Agency's Safeguards System (1965, as provisionally extended in 1966 and 1968)	IAEA Document INFCIRC/66/Rev.2
The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons	IAEA Document INFCIRC/153 (Corr.)
The Physical Protection of Nuclear Material	IAEA Document INFCIRC/225/Rev.1
Communications received from Members regarding the Export of Nuclear Material and of Certain Categories of Equipment and Other Material	IAEA Document INFCIRC/209

Communications Received from Certain Member States regarding Guidelines for the Export of Nuclear Material, Equipment or Technology	IAEA Document INFCIRC/254
IAEA Safeguards: Glossary	IAEA/SG/INF/1
IAEA Safeguards: Guidelines for States' Systems of Accounting for and Control of Nuclear Materials	IAEA/SG/INF/2

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IAEA INTERNATIONAL SAFEGUARDS

AS OF 1 OCTOBER 1981

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green	Non-Nuclear-Weapon States Party to NPT for which NPT Safeguards Agreements Are Not Yet in Force.
red	Non-Nuclear-Weapon States not Party to NPT in which IAEA Safeguards Agreements Are in Force on All Operating and Planned Nuclear Activities.
white	Non-Nuclear-Weapon States not Party to NPT having No Significant Nuclear Activities.
yellow	Non-Nuclear-Weapon States not Party to NPT in which Certain Nuclear Activities are Not under IAEA Safeguards.
violet	Nuclear-Weapon States Party to NPT.
orange	Nuclear-Weapon States not Party to NPT.
■	All nuclear activities currently under IAEA safeguards (non-NPT).
▲	Small unsafeguarded research reactor.

The sole purpose of this map is to illustrate the scope of IAEA safeguards and it does not imply the expression of any opinion whatsoever on the part of the IAEA concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of frontier

CANADA
UNITED STATES OF AMERICA
MEXICO
GREENLAND (DEN.)
ICELAND
IRELAND
NORWAY
SWEDEN
FINLAND
POLAND
UNION OF SOVIET SOCIALIST REPUBLICS
MONGOLIA
PEOPLE'S REPUBLIC OF CHINA
TAIWAN
PHILIPPINES
BURMA
INDIA
PAKISTAN
AFGHANISTAN
IRAN
IRAQ
TURKEY
SAUDI ARABIA
BAHRAIN
EGYPT
LIBYAN ARAB JAMAHIRIYA
TUNISIA
ALGERIA
MOROCCO
MAURITANIA
MALI
NIGER
CHAD
SUDAN
ETHIOPIA
SOMALIA
KENYA
UGANDA
NIGERIA
GHANA
GUINEA
SENEGAL
GAMBIA
CAPE VERDE
CONGO
ZAIRE
ANGOLA
ZAMBIA
MOZAMBIQUE
NAMIBIA
SOUTH AFRICA
MADAGASCAR
AUSTRALIA
NEW ZEALAND
TUVALU
FIJI
SAMOA
TONGA
PACIFIC OCEAN
INDIAN OCEAN
ATLANTIC OCEAN
CUBA
VENEZUELA
ECUADOR
PERU
BOLIVIA
PARAGUAY
URUGUAY
PACIFIC OCEAN

blue Non-Nuclear-Weapon States Party to NPT with NPT Safeguards Agreements in Force

Afghanistan
Australia
Austria
Belgium
Bulgaria
Canada
Costa Rica
Cyprus
Czechoslovakia
Denmark
Dominican Republic
Ecuador
El Salvador
Ethiopia
Fiji
Finland
Gambia
German Democratic Republic
Germany, Federal Republic of
Ghana
Greece
Holy See
Honduras
Hungary
Iceland
Indonesia
Iran
Iraq
Ireland
Italy
Jamaica
Japan
Jordan
Korea, Republic of
Lebanon
Lesotho
Libyan Arab Jamahiriya
Liechtenstein
Luxembourg
Madagascar
Malaysia
Maldives
Mauritius
Mexico
Mongolia
Morocco
Nepal
Netherlands
(including Neth. Antilles)
New Zealand
Nicaragua
Norway
Paraguay
Peru
Philippines
Poland
Portugal
Romania
Samoa
Senegal
Singapore
Sudan
Suriname
Swaziland
Sweden
Switzerland
Thailand
Turkey
Uruguay
Yugoslavia
Zaire

green Non-Nuclear-Weapon States Party to NPT for which NPT Safeguards Agreements Are Not Yet in Force*

Bahamas
Bangladesh
Barbados
Benin
Bolivia
Botswana
Burundi
Central African Republic
Chad
Congo
Democratic Kampuchea
Democratic Yemen
Egypt ▲
Gabon
Guinea-Bissau
Grenada
Guatemala
Haiti
Ivory Coast
Kenya
Lao People's Democratic Republic
Liberia
Mali
Malta
Nigeria
Panama
Rwanda
St. Lucia
San Marino
Sierra Leone
Somalia
Sri Lanka
Syrian Arab Republic
Togo
Tonga
Tunisia
Tuvalu
United Republic of Cameroon
Upper Volta
Venezuela ■
[Taiwan]■

red Non-Nuclear-Weapon States not Party to NPT in which IAEA Safeguards Agreements Are in Force on All Operating and Planned Nuclear Activities

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Argentina
Brazil
Chile
Colombia
Cuba
Democratic People's Republic of Korea
Spain
Viet Nam

white Non-Nuclear-Weapon States not Party to NPT having No Significant Nuclear Activities

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Albania
Algeria
Andorra
Angola
Bahrain
Belize
Bhutan
Burma
Cape Verde
Comoros
Djibouti
Equatorial Guinea
Guinea
Guyana
Kuwait
Malawi
Mauritania
Monaco
Mozambique
Nauru
Niger
Oman
Papua New Guinea
Qatar
Sao Tome and Principe
Saudi Arabia
Seychelles
Trinidad and Tobago
Uganda
United Arab Emirates
United Republic of Tanzania
Yemen Arab Republic
Zambia
Zimbabwe

yellow Non-Nuclear-Weapon States not Party to NPT in which Certain Nuclear Activities are **Not** under IAEA Safeguards

---

India
Israel
Pakistan
South Africa

violet Nuclear-Weapon States Party to NPT

Union of Soviet Socialist Republics
United Kingdom
United States of America

orange Nuclear-Weapon States not Party to NPT

China
France

* Except where indicated, States in this list have no significant nuclear activities.

■ All nuclear activities currently under IAEA safeguards (non-NPT).

▲ Small unsafeguarded research reactor.

Westinghouse Electric Corporation

Francis P Cotter
Vice President
Government Affairs

1801 K Street NW
Washington DC 20006

July 29, 1982

The Honorable Marilyn L. Bouquard
U.S. House of Representatives
2334 Rayburn House Office Building
Washington, D.C. 20515

Dear Congresswoman Bouquard:

Your hearing next Wednesday is designed to address the technical aspects of nuclear non-proliferation.

I have written the attached letter to the Economist which expresses my feelings on the subject.

I would like to suggest that in your opening statement on Wednesday you might focus on some misconceptions. The chemical and mechanical means needed to separate plutonium exist in almost any nation of the world today. This is not something that can be stopped by holding up delivery of a U.S. manufactured computer.

You might announce in your opening statement that you are going to ask the following question of each of your witnesses. You would like a simple yes or no answer.

> "It has been almost forty years since the first plutonium was separated in the United States. This was done before the development of jet aircraft, commercial television or computers. Is it not true that the equipment at Hanford in 1944 used to separate plutonium could be easily found in most developed countries today?"

British Prime Minister Thatcher made these points in September of 1979 at Dounreay, site of the UK Prototype Fast Breeder Reactor.

1. "The PFBR is working well and is constantly being researched to improve it before we go to a larger reactor.
2. "There has been an increasing demand for electricity and we shall be vulnerable to oil supplies unless we find an alternative. The obvious alternative supply that is continuous, which will not run out like fossil fuel, will be the fast breeder."

3. "I pressed the button on the fuel reprocessing plant today - that is for reprocessing fuel for the FBR. No one else in the world has one of these.... The worst thing you can do with plutonium is to leave it lying around. The best thing to do is to burn it - the safest thing is to burn it in a fast breeder reactor."

I believe that this leader understands the proliferation question.

Best wishes,

Frank

Westinghouse
Electric Corporation

Francis P Cotter
Vice President
Government Affairs

1801 K Street NW
Washington DC 20006

July 28, 1982

The Editor
The Economist Newspaper Ltd.
25 St. Jame's Street
London SW1A 1HG, U.K.

Dear Sir:

The article on nuclear proliferation in your July 24 edition seems to accept the trendy notion that the export from the United States of high technology items can lead to the spread of nuclear weapons. Specifically, you suggest that the sale to the Swiss of a computerized control system for a heavy water plant in turn could help Argentina produce plutonium for a nuclear weapon.

Surely you recall that the first plutonium for nuclear weapons was produced in the United States some 37 years ago when electronic computers were not in use. In fact, this weapons grade plutonium was produced before the first practical use of jet engines, helicopters, or commercial television.

The plutonium plants of 1945 at Hanford, Washington, were built with mechanical and chemical technologies now widely understood and with rather simple equipment now available worldwide.

The Economist apparently believes that American export controls will not stop the Soviet Gas Pipeline. Are you confident that these same controls can stop a moderately advanced nation from producing plutonium?

Some 28 years ago President Eisenhower recognized that here we were dealing with knowledge and that book burning or technological isolationism would not work.

Most of the world accepted his multinational approach to preventing the spread of nuclear weapons. It's about time to look back at his plan and see how we can make it even more effective.

Sincerely,

Francis P Cotter

Nuclear proliferation

Death from a salesman

Argentina is now being permitted to buy American and Swiss equipment that will help it to make nuclear weapons. The Washington Post's revelation of the sale by a Massachusetts firm of a computerised control system for a large heavy water plant has been confirmed by a state department spokesman. Rather lamely, he put forward the argument that this system was not specially designed for use in such a plant. Nevertheless, it was quite openly bought for that purpose.

The Reagan administration was able to approve the sale, which would otherwise be banned under the 1978 Nuclear Non-Proliferation Act, only because the control system was ostensibly being sold to the Swiss firm, Sulzer, which is supplying Argentina with the complete heavy water plant. In President Carter's time the Americans had tried to stop the Sulzer deal.

The Swiss government has rejected the argument that "sensitive" equipment should not be sold to countries which—like Argentina—refuse to allow inspection of all their nuclear facilities and reject the 1968 non-proliferation treaty (NPT). And the present American administration, instead of trying to get its treaty partners (such as Switzerland) to respect the NPT, seems more interested in ensuring that American firms will get a piece of the pie.

Argentina's nuclear ambitions, which have been visible ever since its original rejection of the NPT, have been spurred by its disastrous failure to annex the Falklands. When General Galtieri's junta collapsed and the navy and air force refused to fill posts in the new military regime, one major exception was made: the navy, which was running the national atomic energy commission, held on to it. Admiral Carlos Castro Madero, the commission's chairman, has seized on the British use of nuclear-powered submarines in the Falklands conflict as a justification for dropping several heavy hints that he would no longer feel bound by any past pledges about Argentina's nuclear activities remaining strictly non-military.

The admiral says that Argentina will continue to comply with the limited bilateral safeguards agreements which it has had to sign in order to obtain various nuclear materials. But these will hardly inhibit it once it ceases to depend on foreign supplies. It already mines uranium; it expects to be producing heavy water (the moderator needed in its reactors) by 1984; it is building an unsafeguarded reprocessing plant which will extract plutonium from used reactor fuel. The chances of ever inducing it to adhere to the NPT are thus dwindling, all the faster because of other countries' eagerness to make sales that will speed Argentina on its way to nuclear independence.

Apart from the Americans and Swiss, its major suppliers include the Canadians, the West Germans and the Russians (who have just put through a new sale of enriched uranium to Argentina). All these are NPT signatories who do not seem unduly anxious to promote the treaty's aims—not if it means losing a lucrative deal.

South Africa, too, has found some of the treaty partners willing to explore lucrative loopholes. Its atomic energy board recently confirmed that its Koeberg reactor will soon be using a supply of enriched uranium bought from a Swiss firm through an American one in a notably devious transaction. In May the American commerce secretary, Mr Malcolm Baldrige, disclosed that, although there could be no nuclear "co-operation" with South Africa until it accepted the NPT, " a more flexible policy" had been adopted on certain sales to it, and that five sales of sophisticated equipment had been approved in the past two years. Some of the items sold could clearly be used for military nuclear development. South Africa, like India, Israel and Pakistan, is widely held to be closer to acquiring nuclear weapons than Argentina is.

On paper, the Americans' 1978 act not only bars them from exporting certain sensitive nuclear items but also requires them to apply sanctions against any other states that export them. But the Reagan administration's departure from its predecessors' policies now seems to be leading it towards encouraging American exports of a supremely sensitive technology—plutonium reprocessing. The Washington Post has pointed out that this puts the United States in the position of "having a law on its books requiring sanctions against other nations for doing what it is proposing to do itself".

The existing nuclear-armed powers' failure to stop all weapon testing is often cited as one of the things that make it harder to induce other states to renounce these weapons. In 1977 American, Soviet and British negotiators began talks in Geneva about a complete test ban, but little progress was made—largely because of Russian objections to any reliable provision for verification. The Geneva talks have not been resumed since November, 1980. A report in the New York Times on Tuesday that President Reagan had decided not to resume these talks has been described as incorrect by American officials.

However, the same officials are reported as agreeing that, before the test ban talks are resumed, the Americans first want to renegotiate the provisions about verification in the "threshold" treaties that were signed in 1974 and 1976. These two treaties, the second of which dealt with "peaceful" nuclear blasts, banned explosions of more than 150 kilotons. The Americans contend that they cannot, under the present arrangements, know for sure whether Russia has violated the treaties. There is some logic in the argument that Russia will have to accept adequate verification methods for the existing treaties before there will be much point in trying again for a properly verifiable complete test ban. But the new developments will not encourage hopes of obtaining a complete ban that could in turn discourage the wider proliferation of nuclear weapons across the world.

SIXTH
PROGRAM PLAN

PROGRAM FOR TECHNICAL ASSISTANCE TO IAEA SAFEGUARDS

USA

IAEA

Department of Energy

Office of Safeguards & Security

MAY 1, 1982

BROOKHAVEN NATIONAL LABORATORY
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International Safeguards Project Office

PREFACE

The Sixth Program Plan for U.S. Technical Assistance to IAEA Safeguards presents current plans for the Program which began in March 1977. The original plan identified 98 tasks with an additional 196 tasks being added in 1978, 1979, 1980 and 1981. About 212 of these tasks have been completed and 38 have been deleted as mutually agreed upon by the IAEA and the U.S. The remainder of the tasks are in progress.

During the past year, joint IAEA-U.S. meetings were held in the U.S. and in Vienna to review progress on the tasks in the existing plan and to identify other tasks that satisfy urgent needs of the IAEA. As a result of these discussions 13 new tasks were identified and, at the request of IAEA, are included in this Sixth Program Plan. Six other new requests were accommodated in the Plan by revision of currently active tasks. Because of funding limitations initiation of other new tasks identified by the IAEA have had to be postponed, and are not included in this plan. For the same reason, 8 tasks shown as "Active" in this plan were not funded this year and are temporarily on a hold status. These will be initiated as funds become available according to the priorities established by the IAEA.

The major task areas of the Program Plan are directed at five functions of IAEA Safeguards activity:

A. Measurement Technology
B. Training
C. System Studies
D. Information Processing and Evaluation
E. Containment and Surveillance

Because of the reduced number of tasks, there is no longer a division of task areas into sub-groups. Instead, tasks are simply arranged in numerical order.

An index of Tasks has been placed at the back of the document. This list includes all tasks indicating status, i.e., new, current, completed or deleted.

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PROGRAM PLAN FOR U.S. TECHNICAL ASSISTANCE TO THE SAFEGUARDS ACTIVITIES OF THE INTERNATIONAL ATOMIC ENERGY AGENCY

I. The Basis for U.S. Technical Assistance:

The safeguards implemented by the International Atomic Energy Agency (IAEA) are of major importance to the non-proliferation objectives of the United States of America and other nations of the world. Assurance of safeguards effectiveness is mandatory to continued peaceful use of nuclear power. To enhance the ability of the IAEA to apply safeguards effectively, and to ensure that IAEA does not lack technical assistance in critical areas, the U.S. Congress has made available a special authorization for a Program for Technical Assistance to IAEA Safeguards (POTAS).

Substantial U.S. assistance, in addition to that included in POTAS, is also being provided to the IAEA Safeguards Program on the policy level. Such assistance includes: efforts through the Nuclear Suppliers Group to extend the application of IAEA Safeguards; development and promotion of multinational, regional fuel cycle centers including international regimes for spent fuel or plutonium storage; implementation of the U.S. offer to permit application of IAEA Safeguards to all U.S. nuclear facilities except those of direct national security significance; and, perhaps most importantly, strong U.S. support for needed growth of the IAEA Safeguards Program.

The technical assistance which POTAS provides is intended to complement and enhance the methods that the IAEA normally uses to fill safeguards needs. This assistance is to provide quick reaction to identified urgent needs to improve effectiveness where normal IAEA budget channels cannot respond fast enough. Special expertise is made available from other U.S. programs to strengthen IAEA capabilities in areas where expertise is currently limited. Several tasks described in this Program Plan will be accomplished by the U.S. Initiative Program. This program refers to technical developments in the U.S. having possible application to IAEA Safeguards. At an appropriate time these technologies, if found promising, will be transferred to the IAEA for consideration. Members of IAEA staff will be given opportunities to become familiar with actual operating conditions that they will later encounter in the discharge of their safeguards duties. In the future, other needs for U.S. assistance may be found in particular cases, but the ones described above have been identified as being of the highest urgency.

In actual practice, IAEA safeguards are carried out pursuant to Agreements between IAEA and the Member States in which safeguards are applied. In States adhering to the Non-Proliferation Treaty (NPT), as well as States which have only partially accepted international safeguards, each facility subject to IAEA Safeguards is required to maintain complete records and is also required to report certain information to IAEA. IAEA reviews facility records and reports, including design information and nuclear materials accounting information. Independent verification by IAEA includes facility verification and continuing verification of nuclear materials accountancy, including verification by assay of nuclear materials. POTAS includes tasks which will contribute to the effectiveness of this overall, integrated IAEA Safeguards System.

Safeguards, as applied by IAEA, are implemented with the objective of providing detection of any diversion of significant quantities of nuclear material, subject to IAEA Safeguards, from peaceful nuclear activities to the manufacture of nuclear weapons/explosives or for purposes unknown. The hypothetical diversion techniques which the IAEA must be able to detect include:

1. Overstatement of materials removed from safeguards, including wastes.
2. Falsification of records and reports, including the use of floating inventories to conceal the absence of diverted material.
3. Use of accountability uncertainties, including exaggeration of measurement uncertainty, to conceal the absence of diverted material.
4. Understatement of receipts or production at a safeguarded facility.

Although the Non-Proliferation Treaty came into force in March 1970, the methods used by the IAEA in safeguards under the Treaty are still evolving and this evolution can be expected to continue for some time. There are several reasons for the continued change but most changes follow from the slow rate of implementing the Treaty.

POTAS presents a determined attack on known problem areas and successive efforts will address other required actions. The tasks in this program are directed at improving IAEA's effectiveness and timeliness in determining material missing in a State. In the area of measurement technology, specific tasks are being directed to methods that would be used by IAEA staff, and to supplement that staff with cost-free experts. Measurement instruments transported and used by inspectors need to be more reliable and convenient to use, and to be suitable for inventory verification by non-destructive assay of additional and significant forms of nuclear materials. There is an important need for additional surveillance equipment that could give more reliable indication of tampering, and more timely indication of diversion. Development of containment and surveillance capabilities suited to a wider range of nuclear materials and equipment can make substantial contributions to IAEA's safeguards effectiveness. Cost-free experts can help make early and substantial improvements in IAEA systems for analysis of inspection reports. Several planning studies will serve to define methods for safe-guarding facility types to which IAEA Safeguards will be applied in future years. Reviews of the status of U.S. domestic safeguards activities will facilitate the transfer to IAEA of systems and technology now in use or under development in the areas of information transfer, monitoring nuclear operations, and diversion path analyses. Training of State officials and IAEA staff is to receive continued and broadened assistance consistent with future IAEA plans and undertakings.

The POTAS program is a positive response to those areas which were identified for useful technical assistance to IAEA Safeguards in the course of meetings between safeguards officials and technical experts from the IAEA and the United States. The goal of the initial program, formulated during a two-week meeting in November 1976 and a one-week followHup meeting in February 1977, was to provide, as needed, those items of assistance which the IAEA agreed would be useful under existing Safeguards Agreements, and which the U.S. could supply. The program is directed at providing an effective response to IAEA needs.

II. Resources:

Under the leadership of the President of the United States, the Department of State, DOE, ACDA, and NRC have each accepted responsibility for parts of the Program for Technical Assistance to IAEA Safeguards (Figure 1). State is providing policy guidance and, through the Agency for International Development, has sought and obtained funding. DOE has established an International Safeguards Project Office (ISPO), at Brookhaven National Laboratory, for program coordination and task implementation, and DOE, ACDA, and NRC are contributing managerial and technical resources to development and implementation of this Program Plan.

DOE has substantial resources for implementing priority national programs involving technology. In expediting the initiation of this technical assistance program, full use is made of existing DOE laboratory resources. Participating laboratories include: Los Alamos National Laboratory; Sandia National Laboratories; Argonne National Laboratory; Battelle Pacific Northwest Laboratory; Brookhaven National Laboratory; Idaho National Engineering; Monsanto Research Corporation Mound Facility; Oak Ridge National Laboratory; Lawrence Livermore National Laboratory; and others. The safeguards programs at these different laboratories reflect different areas of specialization. In addition, contractors of the U.S. private sector, who have extensive experience in the nuclear safeguards field, are utilized in those tasks for which they are qualified.

DOE, ACDA, and NRC are contributing program management resources and, in addition, are each undertaking new specific tasks and have already initiated tasks now included in this Program Plan. All are providing full information to ISPO on the nature and progress of tasks undertaken. The funding shown for an individual task in the Program Plan is in addition to any funding presently allocated to the task by DOE, ACDA, or NRC. Such funding is shown in parenthesis or explained in footnotes.

III. Definitions:

Many of the tasks described in the Program Plan result in delivery to the IAEA of equipment/techniques and associated manuals, reports and training. The following definitions are intended to clarify the character, limitations, etc. of these task deliverables.

U.S. - IAEA SAFEGUARDS ASSISTANCE

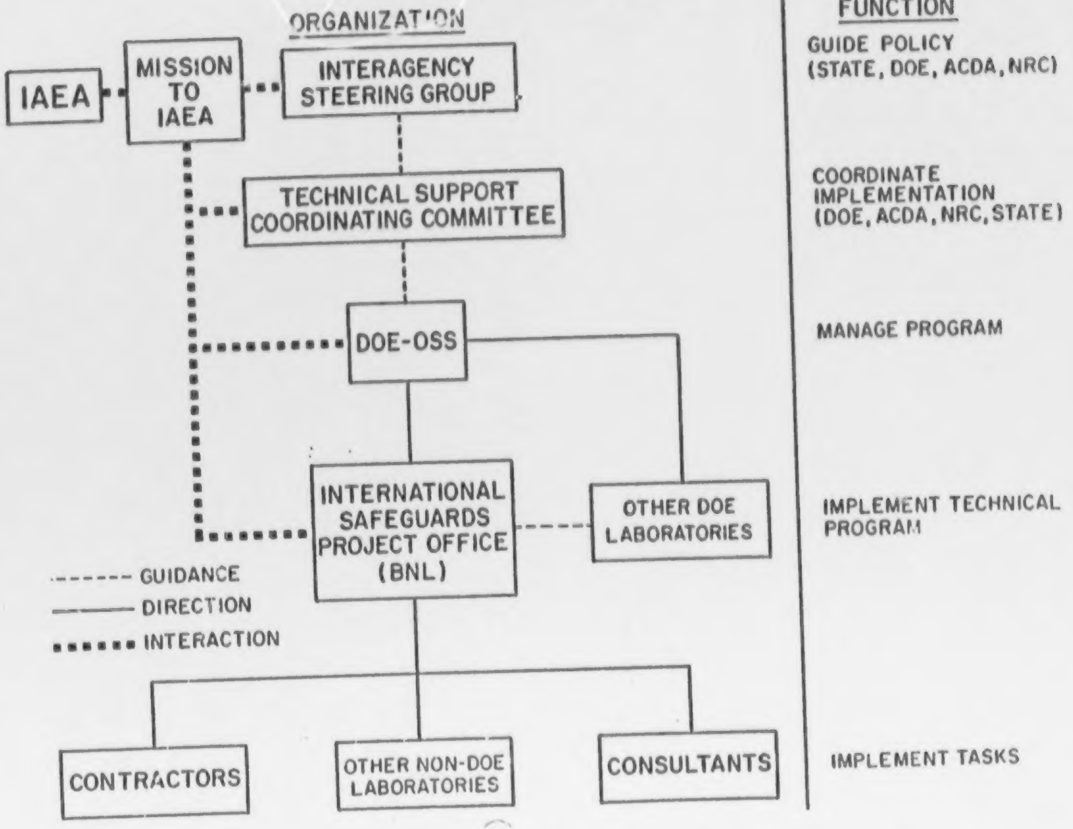
ORGANIZATION
IAEA
MISSION TO IAEA
INTERAGENCY STEERING GROUP
TECHNICAL SUPPORT COORDINATING COMMITTEE
DOE-OSS
INTERNATIONAL SAFEGUARDS PROJECT OFFICE (BNL)
OTHER DOE LABORATORIES
CONTRACTORS
OTHER NON-DOE LABORATORIES
CONSULTANTS
GUIDANCE
DIRECTION
INTERACTION
FUNCTION
GUIDE POLICY (STATE, DOE, ACDA, NRC)
COORDINATE IMPLEMENTATION (DOE, ACDA, NRC, STATE)
MANAGE PROGRAM
IMPLEMENT TECHNICAL PROGRAM
IMPLEMENT TASKS

FIGURE I

EQUIPMENT CLASSIFICATION:

CLASS I: Laboratory Device - The purpose of this equipment is to demonstrate the principle of operation and the nature of the data that will be produced so the IAEA can comment on the approach and future design options. In most cases the equipment will be operated by the designer.

CLASS II: Development Prototype - The purpose of this equipment is to allow joint IAEA/US evaluation, including laboratory and limited field testing. Technical experts at the IAEA will be trained to use the equipment. A preliminary equipment manual will be provided and a preliminary safety analysis will be completed.

CLASS III: Field Evaluation Unit - The purpose of this equipment is twofold: (1) to perform final evaluation of the device prior to developing a production capability, and (2) limited use during IAEA inspections. The unit will have undergone a complete safety and reliability analysis. A complete equipment manual and development report will be provided. Where limited quantities are required to meet IAEA needs, these units could be put into full operation by the IAEA after the field evaluation is complete.

CLASS IV: Production Model - Equipment developed to this point will have complete production drawings, production specifications, test procedures, etc., such that the IAEA can obtain commercial supplier quotes on fabrication, testing and delivery of multiple quantities.

MANUALS, REPORTS:

Equipment Manuals - This manual will include operating instructions, maintenance procedures, and, where appropriate, first-order troubleshooting techniques.

Development Reports - This report will describe the instrument in sufficient detail such that the principles of operation are apparent. Test results, where appropriate, will be included.

TRAINING:

Train selected IAEA personnel in the use and maintenance of specific equipment or techniques. This training would help meet the goal of IAEA establishment of a formal training program for the specific equipment or technique.

IV. Program Plan Tasks:

The major task areas of the Program Plan have been directed at five functions of IAEA Safeguards activity:

A. Measurement Technology
B. Training
C. System Studies
D. Information Processing and Evaluation
E. Containment and Surveillance

ACTIVE TASKS

TASK AREA
"A"

MEASUREMENT TECHNOLOGY

TASK AREA A - Measurement Technology

The methods of measurement of nuclear material used by the IAEA for verification purposes generally need improvement. A substantial amount of material is in forms that are with currrent techniques unmeasurable, and other material can be measured only poorly. The ability to measure essentially all forms of material in the nuclear fuel cycle is necessary if quantitative conclusions are to be drawn on the effectiveness of safeguards. The IAEA staff has identified a number of ways in which they feel they need expert U.S. assistance in areas of measurement technology to accomplish the safeguards objectives. These have been gathered in this Task Area.

The product of this task area will therefore be the introduction into IAEA application of the most useful current technology and equipment for effective verification of nuclear materials. System studies performed in Task Area C, together with other field tests, will provide future guidance to the subtasks for upgrading measurement technology.

The subtasks include:

- Provision of long-term experts to work with the IAEA staff in Vienna in the transfer of measurement technology to be used by inspectors, in the development of methods of data analysis, in the training of inspectors for specialized measurement techniques and instruments, and in the establishment of physical standards and calibration procedures.

- Provision of short-term experts to assist the IAEA with specific problems which arise in the application of measurement technologies.

- Provision of newly developed nondestructive assay equipment and techniques, uniquely suitable for use by inspectors in the field.

- Provision of new radiation detection elements incorporating developed or promising technologies for use in assay instruments with greatly increased portability.

- Field demonstrations of measurement technologies in U.S. facilities. (Through specific agreements, facilities in other countries could be used).

- Assistance to IAEA in conducting implementation plans for placing newly developed equipment into routine use.

TASK AREA A - Measurement Technology

A.47

Subtask:	Prediction of Calorimeter Equilibrium
Contractor:	ANL/Mound
Problem:	Inspectors need a capability to predict the thermal equilibrium endpoint value for the bulk calorimeter to meet requirements for rapid measurement time.
Objective:	Provide pre-programmed modules to assist inspectors in operation and data reduction tasks associated with making calorimetric measurements using equipment provided to the IAEA under Task A.9. Main emphasis is on the end-point prediction for the bulk calorimeter.

Activities:

a. Based on present technology, design and construct software packages which provide equilibrium-prediction programs, upgraded data analysis including electrical calibration, plutonium heat standard normalization, and complete error analysis for the IAEA bulk calorimeter.

b. Test the bulk calorimeter on Pu samples with various thermal time constraints.

c. On basis of the tests, optimize the pre-programmed modules.

d. If requested, demonstrate the unit to selected IAEA personnel. Prepare a report.

e. Deliver the microprocessor programs and three preheaters identical to those provided for unit two in task A.9.

f. Deliver two sample cannisters and a final report to IAEA.

g. Assist IAEA to evaluate the system.

Schedule and Milestones:

1. Start task - April 1979
2. Complete activity (a) - September 1980
3. Complete activity (b) - January 1981
4. Complete activity (c) - July 1981
5. Complete activity (d) - July 1981
6. Complete activity (e) - October 1981
7. Complete activity (f) - February 1982
8. Complete activity (g) - TBD

Funding:

	ANL	Mound	ISPO
To Date:	$105,000	$30,000	$3,000

TASK AREA A - Measurement Technology

A.56

Subtask: Measurement Procedures and Standard Reference Materials to Optimize Implementation of Resin Bead Techniques

Contractor: NBS/ORNL

Problem: The IAEA needs measurement procedures and standard reference materials to help implement the resin bead technique at the laboratory level.

Objective: Establish recommendations for standard measurement methods using the resin-bead technique, and provide characterized resin bead standard reference materials (U, Pu, and U-Pu).

Activities:

a. Review and compile measurement procedures as implemented at this time by laboratories conversant with the resin bead technique.

b. Design a round-robin exercise involving SAL, ORNL, BCNM, and other qualified laboratories (if any) in Member States.

c. Supply the IAEA, for distribution to participating laboratories, with reference materials representing U, Pu and U-Pu loaded resin beads. Material should be representative of samples normally taken by IAEA inspectors.

d. Assist the IAEA in the conduct of round robin exercise, including evaluation of results.

e. Based on experience gained, recommend and prepare standard measurement procedures.

Schedule and Milestones:

1. Start task - June 1979
2. Complete (a) - April 1980
3. Complete (b) - August 1980
4. Complete (c) - May 1981
5. Start (d) - TBD
6. Start (e) - TBD
7. Complete (d) and (e) - TBD

Funding:

	NBS	ORNL
To Date:	$147,000	$85,000

TASK AREA A - Measurement Technology

A.59

Subtask: Air Shipment of Plutonium Samples to Facilitate International Safeguards

Contractor: BNL/ISPO

Problem: An approved method for air shipment of plutonium is needed. Transport of plutonium samples by air is prohibited until containers certified as safe are available. The PAT-I container, certified by NRC, does not appear to be feasible for safeguards samples because of its cost and bulk.

Objective: Develop a method and a container which is suitable for the air transport of gram quantities of plutonium and assist IAEA to implement.

Activities:

Phase I: Container Development

a. Identify the specifications for a method and a container that would have acceptance internationally.

b. Develop design specifications and submit to IAEA for comment.

c. Review and finalize specifications with IAEA.

d. Estimate the cost and time schedule for obtaining containers which could meet the near term needs of IAEA.

Phase II: Implementation

e. Supply five PAT-2 containers to the IAEA with an initial supply of cannisters and quartz sample vials.

f. Supply equipment for preshipping tests of sealing integrity. Provide detailed procedures on placing samples in the PAT-2 for shipment and for removal after shipment. Provide training if required.

g. Provide detailed procedures with examples on accomplishing PAT-2 shipment to Vienna addressing all forms required, authorizations, government offices involved, and procedural time sequences. Specify functions of shipping agent, as applicable. Indicate expected differences in procedure for major IAEA-member state shipping routes.

TASK AREA A - Measurement Technology

A.59 (cont'd)

Schedule and Milestones:

1. Complete Phase I (a-d)* - September 1981
2. Start Phase II (Implementation) - TBD
3. Complete (e) - 1 month
4. Complete (f) - 3 months
5. Complete (g) - 6 months after start of Phase II

Funding:

	SANDIA	ISPO
To Date:	$50,000	$24,000

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* Phase I objective was met by the development and certification of the PAT-2 container by DOE.

TASK AREA A - Measurement Technology

A.70

Subtask: Development of an Inspector Data Verification and Evaluation System for the Automated Electromanometer

Contractor: BNL/TSO

Problem: The equipment and measurement procedures as developed under TASTEX T-E will provide high precision digital data for the input and plutonium product volumes. Inspectors need independent techniques to verify the measurement data generated by the automated electromanometer system and to reduce and analyze such data on a timely and routine basis.

Objective: Develop a tamper-resistant data verification and evaluation system for use by IAEA inspectors, with dedicated computer-based capability for data manipulation and aggregation, as applied to input and plutonium product accountability measurements at a reprocessing plant.

Activities:

a. Based on requirements identified by IAEA, provide recommendations for a computerized measurement system, based on TASTEX T-E. The verification and data evaluation techniques recommended as meeting Agency inspection requirements should be approved by the IAEA.

b. Prepare, in consultation with the IAEA, a detailed work plan for the development of a data verification and evaluation system for use by inspectors that is applicable to the automated electromanometer system. Submit plan to IAEA for approval.

c. Develop specifications for the inspector data evaluation system including equipment requirements, software development, acceptance testing criteria, and system implementation. Submit for approval.

d. With IAEA concurrence, procure required equipment and reference sources identified above.

e. Provide a software system which will include, but is not limited to: computer programs for use with reference sources and validation of the output of the T-E measurement system, cassette tape copying and measurement data reduction and consolidation; in-process flow determination; evaluation of input and product batch size data; and, preparation of routine inspector summary reports. Automated data collection operation is required.

f. Prepare appropriate documentation of the software developed.

g. Conduct tests at a suitable location for system evaluation. Prepare a joint IAEA system evaluation report; modify system as required and update the system documentation.

TASK AREA A - Measurement Technology

A.70 (Cont'd)

Activities: (Cont'd)

h. Demonstrate the system to IAEA personnel at a selected facility. (Arrangements for the demonstration may require assistance from the IAEA).

i. Prepare the final report. Report will document tests and demonstration results. Submit for review and comment prior to release.

Schedule and Milestones:

1. Begin task - May 1979
2. Complete (a) and (b) - November 1979
3. Complete (c) - August 1980
4. Complete (d) and (e) - TBD
5. Complete (f) and (g) - TBD
6. Complete (h) - TBD
7. Complete (i) - TBD

Funding:

To Date: $90,000

TASK AREA A - Measurement Technology

A.79

Subtask: Methods for Adapting K-Edge Densitometer and Gamma Spectrometer for IAEA Applications

Contractor: LANL, LLNL

Problem: In order for the IAEA to utilize in-plant equipment, methods must be established to insure that (1) an independent calibration of the instrument can be made by IAEA personnel, and (2) modifications to the hardware or software that would cause erroneous answers can be detected.

Objective: Perform a study, based on a TASTEX K-edge densitometer and the TASTEX Gamma Spectrometer (of the type installed at PNC) of practical methods to provide (1) periodic instrument calibration independent of the operator, and (2) tamper indicating hardware and software. Make equipment and procedural changes which are consistent with the study.

Activities:

Phase I:

a. Study feasibility of calibrating TASTEX instruments using standards that can be transported by Agency inspectors. If method requires verification of a Pu standard left in custody of plant operator, show how this can be accomplished.

b. Evaluate methods for protection of software and for verification of software integrity.

c. Study methods of incorporating tamper indicating features into TASTEX instruments by both modification of existing design and new design concepts.

d. Test procedures with IAEA participation and select most promising calibration and operation procedures. Train Agency personnel in procedures to be used.

e. Prepare a report on authentication techniques.

Phase II: For the K-Edge Densitometer (conducted under DOE/OSS funding)

a. Supply the IAEA with standards (Ta foils) and additional copies of software on a floppy disc.

TASK AREA A - Measurement Technology

A.79 (cont'd)

Activities: (cont'd)

Phase II: For the K-Edge Densitometer (cont'd)

b. Provide upgraded measurement control software and written recommendations for calibration procedures.

c. Provide hardware for transmission path length check for field testing. Develop a parallel-sided sample cell.

d. Study the use of the mini-MCA as a possible way of authenticating the installed electronics.

e. Recommend alternate portable NDA instruments that could provide a "Method 1" check.

Phase III:

a. Provide the IAEA with the instrument recommended in Phase IIe.

Schedule and Milestones:

Phase I:

1. Complete (a) - December 1981
2. Complete (b) - December 1981
3. Complete (c) - December 1981
4. Complete (d) - October 1981
5. Complete (e) - March 1982

Phase II:

1. Complete (a) - October 1981
2. Complete (b) - June 1982
3. Complete (c) - July 1982
4. Complete (d) - November 1982
5. Complete (e) - January 1983

Phase III:

1. Complete (a) - TBD

Funding:

	LANL	LLNL	ISPO
To Date:	$85,000	$6,000	$5,000

Estimated 1983: TBD

TASK AREA A - Measurement Technology

A.84

Subtask: Qualitative Verification Criteria - Material Authenticity

Contractor: Mound

Problem: There is a need to specify the material properties that must be measured to give the desired level of confidence that the material under examination is authentic.

Objective: Provide a tabulation of the unique or unusual properties of nuclear material in all its relevant physical/chemical forms. Categorize the corresponding level of confidence in the authenticity of the material under examination that would result from measurement of individual properties and combinations of these properties.

Activities:

a. Determine, in consultation with the IAEA, the categories of nuclear material and the relevant physical/chemical forms to be included in the study.

b. Identify the unique and unusual properties of each form of each category of nuclear material included in the study. Provide tabulation to IAEA for comments.

c. Assign subjective levels of confidence in the authenticity of each form and category of nuclear material that would result from measurement of individual properties and from combinations of measured properties from say "Trivial" to "Very High". Provide listing to IAEA for approval.

d. Recommend appropriate measurement programs that would yield confidence in the authenticity of the material under examination at levels in the range from say "Significant" through "High" to "Very High" for each form and category of material included in the study. Submit reports, as developed on each material measurement program, to IAEA.

Schedule and Milestones:

1. Start task - July 1980
2. Complete (a) - August 1980
3. Complete (b) - September 1980
4. Complete (c) - December 1980
5. Complete (d) - September 1982

Funding:

To Date: $70,000

TASK AREA A - Measurement Technology

A.90

Subtask: Access to U.S. Facilities and Calibration Standards

Contractor: LANL

Problem: The IAEA does not have the facilities needed for calibrating nondestructive assay equipment for use in certain applications.

Objective: Provide the IAEA with the means in the U.S. of calibrating NDA equipment for nuclear material measurement.

Activities:

a. Make available nuclear materials, radiation sources, and equipment; assist in establishing procedures for calibrating NDA equipment of interest to the IAEA.

b. Assist the IAEA in the calibration of selected NDA equipment.

Schedule and Milestones:

Continuing Program 1980, 1981, 1982.

Funding:

	LANL	ISPO
To Date:	$105,000	$10,000

TASK AREA A - Measurement Technology

A.95

Subtask: Program for Implementing Use of HLNCC

Contractor: LANL

Problem: IAEA needs to conduct a program for placing the HLNCC into routine use.

Objective: Assist IAEA by providing direct technical support in areas identified in the IAEA Implementation Program Plan

Activities: Assist IAEA in conducting the following implementation plan:

Phase A:

a. In collaboration with the IAEA perform a systematic investigation of noise pickup problems.

b. Incorporate modifications recommended by the study and evaluate effect on noise pickup.

Phase B: Instrument Procurement, Procedures and Training

a. Identify specific instrument needs and application, and determine number of instruments needed.

b. Develop equipment specifications for procurement of systems, formulate and conduct acceptance tests.

c. Develop a program and manual for equipment maintenance. Select test equipment and identify spare parts inventory. Train maintenance staff.

d. Develop procedures including application software for the HP-97 for assay of selected nuclear materials. Identify requirements for physical standards, auxiliary equipment and other apparatus.

e. Test procedures in field and modify, if required. Revise documentation of measurement technique and software as appropriate.

f. Develop a training program and training materials.

Schedule and Milestones:

Phase A:

1. Start Task - March 1981
2. Complete (a) - January 1982
3. Complete (b) - July 1982

TASK AREA A - Measurement Technology

A.95 (Cont'd)

Phase B:

1. Start Task - March 1981
2. Complete (a) - March 1981
3. Complete (b) - May 1981
4. Complete (c) - July 1981
5. Complete (d) - Continuing in 1981
6. Complete (e) - December 1981
7. Complete (f) - September 1981

Funding:

	LANL	ISPO
To Date:	$195,000	$10,000

TASK AREA A - Measurement Technology

A.96

Subtask: Program for Implementing Use of AWCC

Contractor: LANL

Problem: IAEA needs to conduct a program for placing the AWCC into routine use.

Objective: Assist IAEA by providing direct technical support in areas identified in the IAEA Implementation Program Plan.

Activities: Assist IAEA in conducting the following implementation plan:

Phase A: Test and Evaluation

a. In collaboration with the IAEA perform a systematic investigation of noise pickup problems.

b. Incorporate modifications recommended by the study and evaluate effect on noise pickup.

c. Develop a plan and conduct a field test and evaluation of the system.

d. If required make repairs and modifications to the system.

e. Document results of the field tests.

f. Prepare and conduct a seminar and demonstration for IAEA staff.

g. If required, make modifications to the system.

Phase B: Instrument Procurement, Procedures and Training

a. Identify specific instrument needs and application and determine number of instruments needed.

b. Develop equipment specifications for procurement of systems and formulate and conduct acceptance tests.

c. Develop a program and manual for equipment maintenance. Select test equipment and identify spare parts inventory. Train maintenance staff.

d. Develop procedure, including application software for the HP-97 for assay of selected nuclear materials. Identify requirements for physical standards, auxiliary equipment and other apparatus.

e. Test procedures in the field and modify if required. Revise documentation of measurement techniques and software as appropriate.

f. Develop a training program and training materials.

TASK AREA A - Measurement Technology

A.96 (Cont'd)

Schedule and Milestones:

Phase A:

1. Start Task - March 1981
2. Complete (a) - March 1981
3. Complete (b) - March 1981
4. Complete (c) - May 1981
5. Complete (d) - TBD
6. Complete (e) - June 1981
7. Complete (f) - June 1981
8. Complete (g) - TBD

Phase B:

1. Start Task - March 1981
2. Complete (a) - August 1981
3. Complete (b) - September 1982
4. Complete (c) - June 1982
5. Complete (d) - January 1982
6. Complete (e) - June 1982
7. Complete (f) - June 1982

Funding:

	LANL	ISPO
To Date:	$180,000	$13,000

TASK AREA A - Measurement Technology

A.97

Subtask:	Program for Implementing Use of Gamma and Neutron Chambers for Spent Fuel Measurements
Contractor:	LANL
Problem:	IAEA needs to conduct a program for placing the gamma and neutron chambers into routine use.
Objective:	Assist IAEA by providing direct technical support in areas identified in the IAEA Implementation Program Plan.
Activities:	Assist IAEA in conducting the following implementation plan:

Phase A: Test and Evaluation

a. Develop a plan and conduct a field test and evaluation of the system.

b. If required make repairs and modifications to the system.

c. Document results of the field tests.

d. Prepare and conduct a seminar and demonstration for IAEA staff.

e. If required, make modifications to the system.

Phase B: Instrument Procurement, Procedures and Training

a. Identify specific instrument needs and application, and determine number of instruments needed.

b. Develop equipment specifications for procurement of systems, formulate and conduct acceptance tests.

c. Develop a program and manual for equipment maintenance. Select test equipment and identify spare parts inventory. Train maintenance staff.

d. Develop procedures for routine use of the instrument. Identify requirements for auxiliary equipment and other apparatus.

e. Test procedures in the field and modify if required. Revise documentation of measurement techniques and software as appropriate.

f. Establish procedures for packaging, storing and shipping of equipment at the site.

g. Develop a training program and training materials.

TASK AREA A - Measurement Technology

A.97 (Cont'd)

Schedule and Milestones:

Phase A:

1. Start Task - March 1981
2. Complete (a) - July 1981
3. Complete (b) - July 1981
4. Complete (c) - December 1981
5. Complete (d) - July 1981
6. Complete (e) - September 1981

Phase B:

1. Start Task - March 1981
2. Complete (a) - November 1981
3. Complete (b) - June 1982
4. Complete (c) - September 1982
5. Complete (d) - March 1983
6. Complete (e) - March 1983
7. Complete (f) - August 1983
8. Complete (g) - August 1983

Funding:

	LANL	ISPO
To Date:	$160,000	$10,000
Estimated 1983:	$110,000	—

TASK AREA A - Measurement Technology

A.98

Subtask: Program for Implementing Use of Portable Measurement Equipment to Verify UF_6 Mass Determination

Contractor: BNL/TSO

Problem: IAEA needs assistance to place portable weighing equipment in routine field use to determine UF_6 cylinder gross and tare weights

Objective: Assist IAEA by providing direct technical support in areas identified in the IAEA Implementation Program Plan.

Activities: Assist IAEA in conducting the following implementation plan.

Phase A: Test and Evaluation

a. Develop a plan and conduct a field test and evaluation of the system.

b. If required, make repairs and modifications to the system.

c. Document results of the field tests.

d. Prepare and conduct a seminar and demonstration for IAEA staff.

e. If required, make modifications to the system.

Phase B: Instrument Procurement, Procedures and Training

a. Identify specific instrument needs and applications, and determine number of instruments needed.

b. Develop equipment specifications for procurement of systems, formulate and conduct acceptance tests.

c. Develop a program and manual for equipment maintenance. Select test equipment and identify spare parts inventory. Train maintenance staff.

d. Develop procedures for routine use of the instrument. Identify requirements for auxiliary equipment and other apparatus.

e. Establish procedures for packaging, storing and shipping of equipment.

f. Test procedures in field and modify, if required.

g. Develop a training program and training materials.

TASK AREA A - Measurement Technology

A.98 (Cont'd)

Schedule and Milestones:

Phase A:

1. Start Task - March 1981
2. Complete (a) - April 1981
3. Complete (b) - February 1982
4. Complete (c) - April 1982
5. Complete (d) - August 1982
6. Complete (e) - September 1982

Phase B:

1. Start Task - November 1981
2. Complete (a) - May 1982
3. Complete (b) - May 1982
4. Complete (c) - August 1982
5. Complete (d) - May 1982
6. Complete (e) - May 1982
7. Complete (f) - September 1982
8. Complete (g) - September 1982

Funding:

	TSO	ISPO
To Date:	$90,000	$12,000

TASK AREA A - Measurement Technology

A.99

Subtask: Special Measuring Heads for Neutron Coincidence Counting of Plutonium

Contractor: LANL

Problem: Neutron measurements need to be efficiently performed on variously configured arrangments of plutonium.

Objective: Provide the IAEA with special neutron measuring heads for efficiently measuring fast breeder fuel pins stored in trays, measuring plutonium content of small samples of MOX pellets and Pu nitrate, large Pu inventory bottles and FBR fuel assemblies.

Activities:

Phase I: (Pins)

a. In consultation with the IAEA, design a measuring head for fast breeder fuel pins contained in trays.

b. Fabricate and test the measuring head; report the results to the IAEA.

c. Calibrate the system with the participation of selected IAEA personnel.

d. Deliver the system with a procedures and operations manual.

Phase II: Inventory Samples (MOX pellets and Pu nitrate)

a. In consultation with the IAEA, design, construct and test a Class II system for laboratory feasibility tests.

b. Provide the Agency with an informal report on the test results and fix the design of a Class III system in consultation with the IAEA.

c. Construct and calibrate a Class III system.

d. Deliver the Class III system with an instruction manual to the IAEA and train inspectors in its use.

e. Aid the Agency in a field test and evaluation of the equipment and in producing a report.

f. Supply the IAEA with an additional unit for an extended evaluation in the field.

TASK AREA A - Measurement Technology

A.99 (cont'd)

Activities: (cont'd)

Phase III: Measurement Head for Large Pu Nitrate Inventory Bottles:

a. In consultation with IAEA, design a detector head for measuring Pu nitrate in bottles.

b. Fabricate and test the detector head; report results to the IAEA.

c. Calibrate the Class III system with the participation of selected IAEA personnel.

d. Deliver the Class III system and a procedures and operations manual.

e. Aid the Agency in a field test and evaluation of the equipment and in producing a report.

Phase IV: Universal Head for FBR Fuel Assemblies:

a. In consultation with the Agency define measurement problems and operational constraints.

b. Develop design characteristics for the measurement head.

c. Review the design with the Agency.

d. Fabricate two Class III measuring heads, perform preliminary tests and report results to the IAEA.

e. Calibrate the system with the participation of selected IAEA personnel.

f. Deliver two Class III systems with procedures and manuals.

g. Aid the IAEA in a field test and evaluation of the equipment and in producing a report.

Schedule and Milestones:

Phase I: Measurement head for fuel pins.

1. Complete (a) - March 1981
2. Complete (b) - April 1981
3. Complete (c) - July 1981
4. Complete (d) - September 1981

TASK AREA A - Measurement Technology

A.99 (cont'd)

Schedule and Milestones: (cont'd)

Phase II: Portable measurement head for Inventory Samples (MOX pellets and Pu nitrate).

1. Complete (a) - March 1981
2. Complete (b) - April 1981
3. Complete (c) - June 1981
4. Complete (d) - September 1981
5. Complete (e) - December 1981
6. Complete (f) - October 1982

Phase III: Measuring Head for Large Pu Nitrate Bottles.

1. Start Task - March 1982
2. Complete (a) - August 1982
3. Complete (b) - October 1982
4. Complete (c) - December 1982
5. Complete (d) - January 1983
6. Complete (e) - TBD

Phase IV: Universal Head for FBR Fuel Assemblies.

1. Start Task - March 1982
2. Complete (a) - April 1982
3. Complete (b) - June 1982
4. Complete (c) - August 1982
5. Complete (d) - December 1982
6. Complete (e) - March 1983
7. Complete (f) - May 1983
8. Complete (g) - TBD

Funding:

	LANL	ISPO
To Date:	$260,000	$10,000

TASK AREA A - Measurement Technology

A.100

Subtask:	Senior NDA Expert for Coordination of Implementation Plans
Contractor:	BNL/ISPO
Problem:	Expert assistance is needed in the planning, testing, and implementation of NDA equipment such as the HLNCC, AWCC, and the Neutron Collar.
Objective:	Supply a cost-free expert for a period of two years, to assist the IAEA to aid in carrying out the steps of the Agency's implementation plans for various NDA equipment.

Activities:

a. Plan programs for effective transfer of the NDA technology provided by the U.S. Assistance Program.

b. Coordinate the implementation plan activities for the HLNCC and AWCC.

c. Help finalize the implementation plan for the Neutron Collar.

Schedule and Milestones:

1. Begin task - March 1981
2. Begin appointment - September 1981
3. End appointment - July 1983

Funding:

To Date: $110,000

Estimated 1983: $50,000

TASK AREA A - Measurement Technology

A.101

Subtask: NDA/Instruction and Procedures Expert

Contractor: BNL/ISPO

Problem: Inspectors need a set of instructions and procedures for effective use of NDA, Containment and Surveillance (C/S) equipment and techniques.

Objective: Continue the work of Task A.94 by providing a cost-free expert to serve on the IAEA staff for a period of two years.

Activities:

a. Prepare clear and concise procedures manuals for the installation, use, calibration, data evaluation, and maintenance of NDA and C/S equipment for use by inspectors and other IAEA personnel.

b. Participate in selected activities with the IAEA Safeguards staff to gain an understanding of the unique requirements of the IAEA inspectors.

Schedule and Milestones:

1. Start task - May 1981
2. Selection and approval of expert - August 1981
3. Begin appointment - October 1981
4. Extend appointment for 2 months until November 1983

Funding:

To Date: $110,000

TASK AREA A - Measurement Technology

A.102

Subtask: Cost-Free Expert to Assist in Improving Effectiveness and Efficiency of Safeguards.

Contractor: BNL/ISPO

Problem: During the past years the amount of nuclear material subject to IAEA safeguards has continuously increased. In addition, the material is used more frequently and in more complex and advanced nuclear facilities. This tendency is expected to continue. In order to enable the IAEA to apply its safeguards in the most efficient and effective way, more sophisticated instruments, methods and techniques for verification and evaluation as well as concepts, have been developed in member states or are under development. To assist the Deputy Director General for Safeguards in Implementing Advanced Concepts and Techniques, in following-up, as appropriate, recommendations from external advisers and the Safeguards Implementation Report (SIR),in preparing and updating forecasts of budgetary requirements and in other technical/administrative matters, a highly qualified and experienced adviser to the DDG-SG is required.

Objective: Provide expert assistance to the DDG-SG for a period of two years in the field of implementation of new safeguards instruments, techniques and concepts, follow-up of recommendations and forecasting of budgetary activities.

Activities:

a. Select expert.

b. Prepare work plan for the first year, including schedule and milestones for:

1. The updating of the forecast for required resources for advanced safeguards systems for the next 5-10 years.

2. Follow-up actions on recommendations in the SIR or from other advisers, particularly with respect to the near-term actions.

3. Implementation of improvement in safeguarding power reactors, research reactors, and HEU and plutonium in bulk handling facilities, with emphasis on expediting implementation of specific equipment and techniques which are almost available.

c. Perform activities in accordance with the work-plan for the first year.

d. Prepare a work-plan for the second year, based on the results of the first year.

e. Perform activities in accordance with the work-plan for the second year.

TASK AREA A - Measurement Technology

A.102 (cont'd)

Schedule and Milestones:

1. Selection and approval of expert - October 1981
2. Begin appointment to IAEA - June 1982
3. Preparation and agreement of work-plan for first year - July 1982
4. Preparation and agreement of work-plan for second year - April 1983
5. End appointment to IAEA - May 1984

Funding:

To Date: $60,000

Estimated 1983, 1984: $140,000

TASK AREA A - Measurement Technology

A.103

Subtask: Program for Implementing Use of Active Neutron Coincidence Collar.

Contractor: LANL

Problem: IAEA needs to conduct a programme for placing the Active Neutron Coincidence Collar into routine use.

Objective: Assist IAEA by providing direct technical support in areas identified in the IAEA Implementation Programme Plan.

Activities: Assist IAEA in conducting the following implementation plan:

Phase A: Test and Evaluation.

a. Develop a plan and conduct field tests and evaluation of the system.

b. If required make repairs and modifications to the system.

c. Document results of the field tests.

d. Prepare and conduct a seminar and demonstration for IAEA staff.

e. If required, make modifications to the systems and provide necessary software.

Phase B: Instrument Procurement, Procedures and Training.

a. Identify specific instrument needs and application and determine number of instruments needed.

b. Develop equipment specifications for commercial procurement of systems and formulate and conduct acceptance tests.

c. Develop a program and manual for equipment maintenance. Select test equipment and identify spare parts inventory. Train maintenance staff.

d. Develop procedures, including application software for assay of PWR, BWR and WWER types of fuel assemblies. Identify requirements for physical standards, auxiliary equipment and other apparatus.

e. Test procedures in the field and modify if required. Revise documentation of measurement techniques and software as appropriate.

f. Develop a training program and training materials.

TASK AREA A - Measurement Technology

A.103 (cont'd)

Schedule and Milestones:

Phase A:

1. Start Task - March 1981
2. Complete (a) - June 1981 and October 1981
3. Complete (b) - January 1982
4. Complete (c) - January 1982
5. Complete (d) - January 1982
6. Complete (e) - January 1982

Phase B:

1. Start Task - March 1982
2. Complete (a) - June 1982
3. Complete (b) - June 1982
4. Complete (c) - September 1982 (Identical to HLNCC effort)
5. Complete (d) - September 1982
6. Complete (e) - September 1982
7. Complete (f) - December 1982

Funding:

	LANL	ISPO
To Date	$100.000	$8,000
Estimated 1983:	$ 80,000	

TASK AREA A - Measurement Technology

A.104

Subtask: Program for Implementing Use of the LLNL Microprocessor for Pu Isotopic Analysis

Contractor: LLNL

Problem: IAEA needs to conduct a program for placing the microprocessor into routine use. (Developed under Task A.63).

Objective: Assist IAEA by providing direct technical support in areas identified in the IAEA Implementation Program Plan

Activities: Assist IAEA in conducting the following implementation plan:

Phase A: Test and Evaluation

a. Supply the IAEA with three additional Class III microprocessor units with the latest available version of the software.

b. Assist in modifying the IAEA Silena MCA's to make them compatible with the LLNL microprocessor.

c. Develop a plan and conduct field tests to evaluate the system.

d. Document results of the field tests.

e. Prepare and conduct a seminar and demonstration for the IAEA staff.

f. If required, make modifications to the system and the associated software.

Phase B: Instrument Procurement, Procedures and Training

a. Identify specific instrument needs and application, and determine number of instruments needed.

b. Develop equipment specifications for procurement of systems, formulate and conduct acceptance tests.

c. Develop a program and manual for equipment maintenance. Select test equipment and identify spare parts inventory. Train maintenance staff.

d. Develop procedures for routine use of the instrument. Identify requirements for auxiliary equipment and other apparatus.

e. Test procedures in the field and modify if required. Revise documentation of measurement techniques and software.

f. Establish procedures for packaging, storing and shipping of equipment at the site.

g. Develop a training program and training materials.

TASK AREA A - Measurement Technology

A.104 (cont'd)

Schedules and Milestones:

Phase A:

1. Start Phase A - March 1982
2. Complete (a) - October 1982
3. Complete (b) - September 1982
4. Complete (c) - October 1982
5. Complete (d) - October 1982
6. Complete (e) - October 1982
7. Complete (f) - March 1983

Phase B:

1. Start Phase B -
2. Complete (a) - November 1982
3. Complete (b) - May 1983
4. Complete (c) - June 1983
5. Complete (d) - July 1983
6. Complete (e) - September 1983
7. Complete (f) - September 1983
8. Complete (g) - December 1983

Funding:

	LLNL	ISPO
To Date:	$110,000	$5,000
Estimated 1983:	40,000	-

TASK AREA A - Measurement Technology

A.105

Subtask: Program for Implementing Use of the Portable LANL-MCA.

Contractor: LANL

Problem: The IAEA needs to conduct a program for placing the LANL-MCA into routine use.

Objective: Assist the IAEA by providing direct technical support in areas identified in the IAEA Implementation Program Plan.

Activities: Assist the IAEA in conducting the following implementation plan:

Phase A: Software development, test and evaluation

a. Develop microprocessor software and instrument interactive routines for

   i) Enrichment measurements (including UF_6 material) with cladding thickness and type of material correction included.

   ii) U-235 content in MTR fuel and plates.

b. Based on the IAEA evaluation of a similar commercially available MCA (as for example ND-6) evaluate the possibility to include LANL-MCA's software into the commercial unit.

c. Test the programs in the laboratory and supply the Agency with a report on the test.

d. Based on results of (c), modify the three Agency's portable MCA's and provide procedures.

e. Develop a plan and conduct a field test and evaluation of the modified MCA's.

f. Document results of the field tests.

g. Prepare and conduct a seminar and demonstration for IAEA staff.

h. If required make modifications to the MCA's.

Phase B: Instrument Procurement, Procedures and Training

a. Identify specific instrument needs and application, and determine number of instruments needed.

b. Develop equipment specifications for procurement of MCA units, formulate and conduct acceptance tests.

c. Transfer LANL software into the commercially available unit.

TASK AREA A - Measurement Technology

A.105 (cont'd)

Phase B: (cont'd)

d. Develop a program for equipment maintenance. Select test equipment and assist with identification of a spare parts inventory. Assist in training of maintenance staff.

e. Develop procedures for routine use of the instrument. Identify requirements for auxiliary equipment and other apparatus.

f. Test procedures in the field and modify if required. Revise documentation of measurement techniques and software.

g. Establish procedures for packaging, storing and shipping of equipment at the site.

h. Develop a training program and training materials.

Schedule and Milestones:

Phase A:

1. Start Phase A - May 1982 (work in progress under DOE program)
2. Complete (a) - September 1982
3. Complete (b) - September 1982
4. Complete (c) - October 1982
5. Complete (d) - December 1982
6. Complete (e) - October 1982
7. Complete (f) - November 1982
8. Complete (g) - October 1982
9. Complete (h) - TBD

Phase B:

1. Start Phase B - May 1982
2. Complete (a) - October 1982
3. Complete (b) - December 1982
4. Complete (c) - February 1983
5. Complete (d) - May 1983
6. Complete (e) - May 1983
7. Complete (f) - July 1983
8. Complete (g) - October 1983
9. Complete (h) - November 1983

Funding:

		LANL	ISPO
To Date:	Phase A	$100,000	$10,000
	Phase B	TBD	TBD

TASK AREA A - Measurement Technology

A.106

Subtask: Management of Technical Support

Contractor: ISPO

Problem: The expansion of the scope of IAEA safeguards will require a significant increase in the number of inspectors and the use of new equipment and techniques. To assure efficient implementation of new manpower and technology, the IAEA needs assistance in formulating an improved program for technical management of its support to safeguards operations.

Objective: Assist the IAEA in formulating an improved program for management of technical support to safeguards operations.

Activities:

a. Review and document current IAEA practices for providing technical support to the Divisions of Operations, in particular, support functions relating to equipment testing, procurement and maintenance.

b. In collaboration with designated IAEA staff, and based on IAEA requirements for inspectors, review IAEA plans for expanded safeguards activities, and assist in preparation of an updated, 5 year estimate of technical support requirements.

c. Assist IAEA in identifying areas where improvements can be made in current technical support practices, and recommend a revised program for management of technical support.

d. Prepare a final report and review results with IAEA.

Schedule and Milestones:

1. Start task - July 1982
2. Complete (a) - October 1982
3. Complete (b) - November 1982
4. Complete (c) - December 1982
5. Final report - February 1983

Funding:

To Date: $80,000

ACTIVE TASKS

TASK AREA
"B"

TRAINING

TASK AREA B - Training

The IAEA faces two important areas in which training must be conducted. The first of these is the training of new inspectors, many of whom are from parts of the world in which little opportunity has existed for developing familiarity with a nuclear industry, and almost all of whom are unfamiliar with safeguards and the IAEA system. The second is the training of personnel in Member States who interface with the IAEA's system. The latter problem is compounded because in a great many cases the Member States have only rudimentary safeguards systems which, if the IAEA methods are to be effective, must be developed further.

With the hiring of a substantial number of new inspectors, an increase in quantity and quality of the training is needed. In recognition of this need, the the IAEA has established under the Deputy Director General for Safeguards a new group called the Safeguards Training Section to be responsible for all training matters.

The tasks in this section are directed to assistance in developing the formal schedules and course content, and to supplying on a short term basis expert lecturers where IAEA staff is not sufficient or is not available. Some additional training will be available in the U.S., where local expertise and practical operations provide a more suitable base than can be found at the IAEA.

U.S. assistance is being provided in the form of experts to assist in planning IAEA courses and as lecturers for these courses, by providing teaching aids and equipment, and by supplementing the IAEA training programs by providing specialized courses or individual training at DOE laboratories and other facilities. Some support is also aimed at providing field training in the use of NDA instruments and other equipment used by IAEA inspectors.

U.S. nuclear facilities are also used for familiarization courses to give the IAEA staff a better understanding of facility operations.

TASK AREA B - Training

B.15

Subtask: Training for Nuclear Fuel Plant Processes

Contractor: ISPO

Problem: Inspectors need to be familiar with the operation of fuel fabrication and reprocessing facilities so that they can effectively perform verification tasks at these plants.

Objective: Provide, for IAEA inspectors, courses related to reprocessing and fuel fabrication plants designed to provide familiarization with principles of operation of such plants, particularly in relation to verification functions by IAEA.

Activities:

a. Identify a reprocessing and a fuel fabrication facility where courses could be conducted.

b. Formulate a course at each facility in cooperation with the Department of Safeguards Training Officer.

c. Conduct courses.

Schedule and Milestones:

1. Begin task - April 1980
2. Complete (a) - May 1980 (First course only)
3. Complete (b) - December 1980 (First course only)
4. Complete (c) - June 1981 (First course only)
5. Complete additional courses - TBD

Funding:

To Date: $75,000

TASK AREA B - Training

B.19

Subtask: IAEA Participation in U.S.-Sponsored Training Courses

Contractor: BNL/ISPO/LANL

Problem: After undergoing basic training in safeguards technologies, inspectors require more advanced and specific training, notably in those NDA techniques developed for the measurement of nuclear materials.

Objective: Provide the opportunity for IAEA staff to participate in training programs on NDA instruments, methods, and techniques.

Activities:

a. Conduct courses at Los Alamos to train IAEA staff in the use of NDA instruments used by IAEA inspectors.

Schedule and Milestones:

Continuing task 1980, 1981, 1982.

Funding:

	ISPO	LANL
To Date:	$400,000	$325,000

TASK AREA B - Training

B.24

Subtask: Cost-Free Training Expert

Contractor: BNL/ISPO

Problem: The IAEA needs a qualified instructor to assist the Head, Safeguards Training Unit to continue the development of Introductory Courses from available material and provide effectiveness in classroom presentation.

Objective: Supply a cost-free expert for one year to assist in organizing the lecture notes, session objectives and to complete a Course Manual for the "Introductory Course on Agency Safeguards".

Activities:

a. Arrange a replacement for the present cost-free expert provided by Task B.17.

b. Arrange appointment for new expert one month before end of appointment of present expert.

Schedule and Milestones:

1. Selection and approval of expert - May 1981
2. Begin appointment to IAEA - April 1982
3. End appointment to IAEA - April 1983

Funding:

To Date: $60,000

Estimated 1983: $20,000

TASK AREA B - Training

B.25

Subtask: Cost-Free Training Expert

Contractor: BNL/ISPO

Problem: The IAEA needs a qualified training specialist to assist the Training Unit professionals in developing instructional materials for use in individual or group training sessions.

Objectives: Supply a cost-free expert for two years to develop instructional materials intended for inspectors. The function requires competent instructional design methodology.

Activities:

a. Manage the instructional television (ITV) facility.

b. Work with the training staff and other subject matter experts to develop instructional material including video tapes.

c. Perform instructional design activities associated with the development of instructional materials.

d. Where necessary coordinate the commercial production of instructional material to ensure that the Agency requirements are satisfied.

Schedule and Milestones:

1. Selection and approval of expert - August 1981
2. Begin appointment to IAEA - October 1981
3. Extend appointment for one year until - October 1983

Funding:

To Date: $100,000

Estimated 1983: $60,000

TASK AREA B - Training

B.26

Subtask: Cost-Free Training Expert

Contractor: BNL/ISPO

Problem: The IAEA needs a qualified training specialist in the field of administration and personnel management to assist in the training of managerial staff within the Department of Safeguards in the adoption and implementation of modern management techniques as well as to assist in the adoption and initial application of such techniques.

Objectives: Supply a cost-free expert for two years to formulate personnel management and admininistrative practices and assist in their adoption and initial implementation. The function requires broad experience in field and specific experience with international organizations.

Activities:

a. Participate in the work of the Department's management and administrative group within the Section for Standardization and Administrative Support.

b. Take initiative and responsibility for the formulation of improved administrative and personnel management practices for the Department.

c. Assist in obtaining input and concurrence for such practices from the Department as a whole.

d. Assist in the process of adopting and initially implementing the above-mentioned practices.

e. Assist in ensuring uniform interpretation and implementation of the above-mentioned practices.

f. Assist in ensuring that feed-back arising from experience in their application is suitably reflected in amendments or expansion of such practices.

Schedule and Milestones:

1. Selection and approval of expert - October 1981
2. Begin appointment to IAEA - January 1982
3. End appointment to IAEA - December 1983

Funding:

To Date: $55,000

Estimated 1983: $55,000

TASK AREA B - Training

B.27

Subtask: Cost-Free Training Expert

Contractor: BNL/ISPO

Problem: The training in NDA instruments at Agency's ICAS needs a qualified specialist to organize exercises, comprising the instructor and trainee parts.

Objectives: Supply a cost-free expert for a period of two years to develop a training manual for the current NDA equipment used in the ICAS.

Activities:

a. Work with the Safeguard Training Section, on the design of the Manual.

b. Draft the Manual.

c. Participate as instructor in the NDA instruments course for IAEA inspectors.

Schedule and Milestones:

1. Selection and approval of expert - March 1982
2. Begin appointment to IAEA - August 1982
3. End appointment to IAEA - July 1984

Funding:

To Date: $90,000

Estimated 1983, 1984: $100,000

TASK AREA B - Training

B.28

Subtask: Facility Familiarization Information

Contractor: BNL/ISPO

Problem: Some newly recruited inspectors present a lack of knowledge in basic principles, conception, structure and operation of some part of the fuel cycle. The specific lectures on the different type of facilities cannot be extended to cope with this need for many reasons.

Objective: Provide organized information packets on the five major types of facilities (research and power reactors, fuel fabrication plant, reprocessing plant and critical assembly). Self-instructional information should be specially prepared for new inspectors and include a facility description, principles of operation, fuel flow diagram, etc., in order to bring the trainee to the desirable level. The use of such aids can be made in periods not allocated to the Introductory Course Schedule.

Activities:

a. Submit a draft of the proposed packages to IAEA for review.

b. Review and discuss with IAEA.

c. Complete preparation of packages.

Schedule and Milestones:

1. Start Task - July 1982
2. Complete activity (a) - September 1982
3. Complete activity (b) - October 1982
4. Complete activity (c) - February 1983

Funding:

To Date: $75,000

TASK AREA B - Training

B.29

Subtask: In Field Training on Verification of HEU inventories of Bulk Handling Facilities

Contractor: ISPO

Problem: Inspectors require specific training in NDA techniques recently developed for the verification of HEU inventories of bulk handling facilities.

Objective: Provide a training course for inspectors to be conducted at a HEU fuel fabrication facility.

Activities:

a. Identify a facility in the U.S. where the in field training could be given and submit a work plan to IAEA for review and comment.

b. Formulate verification measures which utilize equipment developed for verification of HEU. The NDA measures will be used in concert with procedures for verification of facility values.

c. Prepare a detailed training course that incorporates procedures for the selected set of inspection activities and submit to IAEA for review.

d. Test the training program at the selected bulk handling facility with participation of selected IAEA personnel.

e. Provide a training course manual which describes the conduct of the training exercises.

Schedule and Milestones:

1. Start task - October 1982
2. Complete (a) - January 1983
3. Complete (b) - March 1983
4. Complete (c) - May 1983
5. Complete (d) - TBD
6. Complete (e) - TBD

Funding:

	LANL	Contractor	ISPO
To Date:	$30,000	$10,000	$ 6,000
Estimated: 1983	$85,000	$40,000	$34,000

TASK AREA B - Training

B.30

Subtask: In Field Training on Verification of Pu Inventories in a MOX Fuel Fabrication Facility

Contractor: LANL/ANL/HEDL

Problem: Inspectors require specific training in NDA techniques recently developed for the verification of Pu inventories of bulk handling facilities.

Objective: Provide a training course for inspectors to be conducted at a Pu fuel fabrication facility.

Activities:

a. Identify a facility in the U.S. where the in field training could be given and submit a work plan to IAEA for review and comment.

b. Formulate verification measures which utilize equipment developed for verification of Pu. The NDA measures will be used in concert with procedures for verification of facility values.

c. Prepare a detailed training course that incorporated procedures for the selected of inspection activities and submit to IAEA for review.

d. Test the training program at the selected bulk handling facility with participation of selected IAEA personnel.

e. Provide a training course manual which describes the conduct of the training exercises.

f. Conduct additional training courses.

Schedule and Milestones:

1. Start task - June 1982
2. Complete (a) - July 1982
3. Complete (b) - August 1982
4. Complete (c) - December 1982
5. Complete (d) - March 1983
6. Complete (e) - April 1983
7. Complete (f) - TBD

Funding:

		LANL	ANL	HEDL	ISPO
To Date:		$75,000	-	$30,000	$ 6,000
Estimated:	1983	$75,000		$30,000	$30,000

ACTIVE TASKS

TASK AREA
"C"

SYSTEM STUDIES

TASK AREA C - System Studies

The present application of IAEA Safeguards is aimed at meeting the provisions of Agreements concluded under INFCIRC/66 and INFCIRC/153. The methods that have been developed so far, and are in use at this time, were mainly based on theoretical developments, which have not been thoroughly tested against practical circumstances. In early application of these methods the IAEA has come to recognize some problems and has moved to correct some of these. At the same time it is recognized that the imminent need to safeguard new kinds of facilities and fuel cycles will bring new problems, especially when very large quantities of nuclear material are involved. Further, development is needed to improve safeguards in the framework of present as well as future objectives.

The system studies in this Task Area assist in identifying the effectiveness of current safeguards measures and provide a basis for upgrading within the framework of present IAEA Safeguards Agreements. These studies also indicate where there may be limitations of the existing Agreements and provide a basis for an expanded safeguards program under revised and new Agreements.

The studies assist the IAEA in developing plans for meeting its near term objective and for preparing a master plan for meeting long term objectives.

The Tasks include:

- Studies designed to examine systematically the activities that are required to apply IAEA Safeguards, to test their effectiveness, and to provide a basis for their improvement. These studies are aimed at providing guidance in meeting both near term and long term objectives. The use of U.S. facilities in some of these studies provides the IAEA and U.S. valuable experience for future implementation of IAEA Safeguards at U.S. facilities.

- Special short term studies performed with the IAEA in Vienna. These studies are aimed at assisting the IAEA in meeting near term objectives.

- Fuel cycle studies, to provide analysis of the application of safeguards on a generic basis and to develop fuel cycle specific models for assessing safeguards effectiveness.

- General system analysis models, for forecasting the application of IAEA inspection effort and for assessing the impact of safeguards criteria.

TASK AREA C - System Studies

C.22

Subtask: Evaluation and Quantification of Safeguards Effectiveness

Contractor: BNL/TSO

Problem: IAEA needs a method for expressing in mathematical terms the effectiveness of various inspection activities.

Objective: Phase I: Develop a methodology for expressing quantitatively the effectivaness of seals, surveillance cameras, records auditing, and other inspection procedures that are not performed on a statistical sampling basis.

Phase II: Modify initial case study to consider the following additional PWR features: (1) fresh MOX fuel; (2) fuel assemblies capable of being dismantled; and (3) cases where seals cannot be applied to the reactor missile shield or accessed during power-on operations.

Activities:

Phase I: For each of the generic facilities identified by IAEA, the evaluation and quantification of safeguards effectiveness will be accomplished by:

1. Development of fault tree models showing all identified and credible diversion paths.
2. Identification of the essential inspection activities which together constitute the IAEA's Safeguards strategy, and applying these activities to the fault tree models.
3. Development of means of expressing mathematically the effectiveness of each fault tree path and related inspection activity.
4. Identification of paths and inspection steps which are interdependent, and development of means to mathematically express this interdependency.
5. Study of the effectiveness of the various safeguards strategies developed in (3) and (4) above, including variations which may be considered or required on political/legal basis.

The task activities include:

a. Prepare a preliminary draft of the LWR analysis and review methodology with IAEA; determine other generic facilities to be evaluated.

b. Complete analysis of LWR facility and provide IAEA with draft report.

c. Complete analysis of other facilities and provide IAEA with draft reports.

d. Complete final report, including all facilities of interest to IAEA.

TASK AREA C - System Studies

C.22 (Cont'd)

Activities: (Cont'd)

Phase II:

a. Complete draft interim report on fuel disassembly case.

b. Complete draft final report on fuel disassembly case.

c. Complete draft interim report on MOX fuel and inaccessible core cases.

d. Complete draft combined report for (b) and (c).

e. Publish final report.

Schedule and Milestones:

Phase I:

1. Start Task - May 1978
2. Complete (a) - August 1978
3. Complete (b) - February 1979
4. Complete (c) - November 1980
5. Complete (d) - June 1981

Phase II:

1. Start Phase II - January 1982
2. Distribute draft interim report (a) - August 1982
3. Distribute draft report (b) - September 1982
4. Distribute draft interim report (c) - November 1982
5. Distribute draft combined report (d) - January 1983
6. Distribute final report - February 1983

Funding:

To Date: $230,000

TASK AREA C - System Studies

C.28

Subtask: Models for Safeguarding Generic Types of Facilities

Contractor: BNL/ISPO

Problem: The IAEA needs to prepare a set of models for safeguarding generic types of facilities to meet the IAEA objectives and criteria.

Objective: Supply the IAEA with a cost-free expert in Vienna for a period of 3 years to assist the IAEA in completing a set of models for power reactors, research reactors and critical assemblies and for developing a model for a generic low enriched uranium fuel fabrication facility.

Activities:

a. Provide IAEA with final draft of model inspection procedures for boiling water reactors.

b. Provide IAEA with final draft of model inspection procedures for light water reactors.

c. Provide IAEA with final draft of model inspection procedures for research reactors and critical assemblies.

d. Prepare draft of IAEA inspector actions to resolve anomalies.

e. Prepare draft model inspection activities to meet Agency goals and objectives at a generic low enriched uranium fuel fabrication facility.

Schedule and Milestones:

1. Start of Task - May 1980
2. Begin appointment to IAEA - July 1980
3. Extend contract for two years until - June 1983

Funding:

To Date: $220,000

Estimated 1983: $50,000

TASK AREA C - System Studies

C.31

Subtask: Development of Guidelines for Practical Implementation of the Elements of SSAC.

Contractor: BNL/TSO

Problem: The IAEA needs to provide Member States with guidelines for practical implementation of the principal elements of their SSAC.

Objective: Assist the IAEA in preparing a series of guides which will communicate to Member States a detailed and explicit exposition of those elements of SSAC that are relevant to the application of IAEA safeguards.

Activities:

Phase I: Guides for Mixed Oxide Fabrication Facility.

The main goal is the preparation of detailed guidelines on the functioning of SSAC's and recommendations on particular aspects of SSAC operations. To be prepared is a set of recommendations as extensive as possible and with the necessary detail, for nuclear material control and accounting systems for the generic types of facilities. Specific procedures related to accounting for and control of nuclear material are to be described. Detailed examples of systems, procedures, and records will be given. A system of facility documentation satisfying Agency needs is one element to be addressed.

a. Prepare preliminary guide and review with IAEA.

b. Prepare a work plan and submit to IAEA. Coordinate with Task C.49 cost-free expert.

c. Prepare draft guides addressing a generic bulk processing facility for MOX. Guide should recommend systems, procedures and relevant documentation that would satisfy the relevant obligations contained in Safeguards Agreements. Examples should be included but it should be recognized that other means may also satisfy IAEA requirements. Recommendations should be consistent with good industrial practice.

The final product of the SSAC guideline effort should be consistent with studies on the IAEA safeguards assessment methodology. There should be an appendix which shows how the recommendations are sufficient for the observation of the anomalies identified in the safeguards case studies. The various system elements should be identified as to whether they are required by the INFCIRC/153 type agreement, and/or required by INFCIRC/66 type agreements, not required by the agreement, but convenient for application of IAEA safeguards, or whether they are not needed for IAEA safeguards at all, but are convenient for facility or state purposes.

TASK AREA C - System Studies

C.31 (Cont'd)

Activities: (cont'd)

The necessity of system elements for IAEA safeguards would be distinquished as to those elements needed for closing the material balance, those for observing anomalies identified in the case studies, and those needed for follow-up actions to resolve observed anomalies. Sufficient rationale should be provided for the individual system elements to enable a facility operator to understand their importance.

d. Review drafts with IAEA.

e. Submit final report.

Phase II: TBD

Schedule and Milestones:

Phase I:

1. Start task - January 1981
2. Complete (a) - September 1981
3. Complete (b) - May 1982
4. Complete (c) through (e) - June 1983

Phase II: TBD

Funding:

To Date: $ 222,000

Estimated 1983: TBD

TASK AREA C - System Studies

C.46

Subtask: Computerization of PWR Anomaly Assessment Modules

Contractor: BNL/TSO

Problem: The IAEA requires assistance to implement its DESIGN and EVALUATION assessment methodology for PWR's.

Objective: Develop an interactive computer program for use on the IAEA computer system, to perform various safeguards assessment methodology functions and assess the DESIGN capability as applied to PWR's.

Activities:

a. Starting with the PWR Case Study, develop an appropriate computer code module for each anomaly, for a priori (DESIGN) and a posteriori (EVALUATION) assessment.

b. For each type of routine periodic inspection (Physical Inventory Verification (PIV), Interim, or Flow Verification) link the appropriate modules together in a manner permitting assessment of each individual inspection (inspection assessment code).

c. Compute the probability of detecting each anomaly for the specified set, and relate to appropriate diversion paths.

d. Group according to Technical Complexity Index (TCI).

e. Plot histogram of detection probabilities vs. diversion paths for each TCI. For EVALUATION uses, compare performance to capability.

f. Provide a facility annual summary code to assess capability and performance for all inspections over the period of one year.

g. Existing Agency computer terminals in the regional sections are to be utilized.

h. Codes developed are to be brought on-line on the Agency's computer.

i. The program is to be documented and training aids are to be provided.

j. Agency staff are to be trained in the use of the code.

Schedule and Milestones:

1. Initial discussion in Vienna 1 week - December 1981
2. Develop preliminary codes - May 1982
3. Spend 6 weeks in Vienna; bring codes on line, training staff - June 1982
4. Document in final report; provide training aids - September 1982

Funding:

To Date: $80,000

TASK AREA C - System Studies

C.47

Subtask: Develop Safeguards Approach for a Medium Sized Reprocessing Plant by Application of Safeguards Effectiveness Assessment Methodology.

Contractor: BNL/TSO

Problem: The IAEA needs assistance in implementing recommendations of the IWG-RPS for reference reprocessing facilities, applying presently developed IAEA safeguards effectiveness assessment methodology.

Objective: Provide assistance in documentation of effective and acceptable IAEA safeguards systems for a reference medium sized irradiated fuel reprocessing plant, applying currently available safeguards techniques in the framework of the IAEA safeguards effectiveness assessment methodology. Identification would be made of specific improvements possible by incorporation of advanced safeguards techniques. The primary objective is a safeguards approach for a reprocessing facility of about 200 tons per year throughput. Possible adaptation of the safeguards approach to anticipated future facilities having 800 to 1000 tons per year throughput would be examined following conclusion of the study for the 200 ton throughput facility.

Activities:

a. Prepare a work-plan and obtain IAEA concurrence.

b. Prepare a preliminary draft report covering the following components:

(1) Facility description covering pertinent characteristics and safeguards constraints. Documentation of the reference facility description should be consistent with previous reports such as STR-89.

(2) Safeguards objectives.

(3) Description of the safeguards approach which includes:

- a complete listing of feasible inspection activities related to examination of records and reports, material verification, and surveillance,
- statement of the containment measurements utilized, and
- a listing of the frequency and types of inspections.

TASK AREA C - System Studies

C.47 (cont'd)

Activities: (cont'd)

The safeguards approach will include only safeguards procedures which have currently been accepted and implemented or which one reasonably could implement in the near future. The safeguards approach also includes a list of the anomalies which will be examined for by the inspector and the decision criteria related to each anomaly. To the extent possible, the follow-up actions to be taken by the inspector to reduce the probability of false positive conclusions arising from innocent causes should be included.

(4) Diversion path analysis identifying feasible diversion paths and concealment possibilities with the corresponding observable anomalies and technical complexity values, addressing the related inspection activities, follow-up actions, and anomaly detection probabilities. Those paths which relate to physical introduction or removal of plutonium through routes other than defined key measurement points, or through KMPs without declared measurements being made, would be included. The report would identify IAEA needs for design information and its verification.

(5) Implementation assessment approach with a priority evaluation of inspection activities for effective allocation of inspection resources.

c. With IAEA comments on draft report, prepare final report.

d. Provide an evalation of safeguards approach improvements possible by incorporation of advanced safeguards techniques which have been sufficiently studied in detail to permit a rational estimation of their feasibility and capabilities.

e. If the evaluation in (d) indicates a need substantiated by IAEA review, repeat (a) through (c) with the specific advanced techniques agreed as important to IAEA objectives.

f. Provide an evaluation of changes in the safeguards approach needed for a 800 to 1000 tons per year throughput facility, using the reference facility design supplied by the IAEA.

g. If the evaluation in (f) indicates a need substantiated by IAEA review, repeat (a) through (c) for the larger reprocessing facility.

Schedule and Milestones:

1. Start task - October 1981
2. Complete (a) - February 1982
3. Complete (b) - August 1982
4. Complete (c) - November 1982
5. Complete (d) - December 1982
6. Advanced techniques and large facilities (e through g) - TBD

Funding:

To Date: $200,000

TASK AREA C - System Studies

C.48

Subtask: Application of Safeguards Effectiveness Assessment Methodology for Mixed-Oxide Fuel Fabrication Facilities

Contractor: BNL/TSO

Problem: The IAEA needs assistance in documenting the safeguards approach in STR-89, "Some Safeguards Considerations for a Reference Mixed Oxide Fuel Element Fabrication Plant with an Annual Throughput of 500 kg PuO_2," covering comprehensive design, implementation, and performance assessments in accordance with the recently developed IAEA safeguards effectiveness assessment methodology.

Objective: Provide assistance in the documentation of an effective and acceptable IAEA system for a reference mixed-oxide fuel fabrication facility, applying currently available safeguards techniques in the framework of the IAEA safeguards effectiveness assessment methodology.

Activities:

a. Prepare a work-plan and obtain IAEA concurrence.

b. Prepare a preliminary draft report documenting the proposed safeguards approach and covering the following components:

(1) Facility description covering pertinent characteristics and safeguards constraints. Documentation of the reference facility description will be based on the report, STR-89.

(2) Safeguards objectives.

(3) Description of the safeguards approach with complete listing of feasible inspection activities, records and reports, material verification, surveillance and containment activities, addressing frequency and types of inspections, and using only safeguards procedures which have currently been accepted and either are currently being implemented or reasonably could be implemented in the near future.

(4) Diversion path analysis identifying feasible diversion paths and concealment possibilities with the corresponding observable anomalies and technical complexity values, addressing the related inspection activities, follow-up actions, and anomaly detection probabilities. Those paths which relate to physical introduction or removal of plutonium through routes other than defined key measurement points, or through KMPs without declared measurements being made, would be included. The report would identify IAEA needs for design information and its verification.

TASK AREA C - System Studies

C.48 (cont'd)

Activities: (cont'd)

(5) Implementation assessment approach with a priority evaluation of inspection activities for effective allocation of inspection resources.

(6) Performance assessment approach to determine actual effectiveness of each inspection and to determine the performance over a 12 month period in terms of diversion detection capability achieved and the timeliness of detection capability maintained.

c. With IAEA comments on the draft report, prepare final report.

Schedule and Milestones:

1. Start task - October 1981
2. Complete (a) - February 1982
3. Complete (b) - July 1982
4. Complete (c) - October 1982

Funding:

To Date: $40,000

TASK AREA C - System Studies

C.49

Subtask: Coordination and Implementation of Guidelines for Practical Implementation of the Elements of SSAC.

Contractor: BNL/ISPO

Problem: The IAEA needs to provide Member States with guidelines for practical implementation of the principal elements of their SSAC.

Objective: Provide a cost-free expert for a period of two years to assist the IAEA in preparing a series of guides, and coordinate within the IAEA these guides, which will be communicated to Member States as detailed and explicit expositions of those elements of SSAC that are relevant to the application of IAEA safeguards.

Activities:

a. Coordinate the preparation of guides for Mixed Oxide Facilities.

1. Review existing draft guides and relevant documentation in consultation with the IAEA Development, Operations, Information Treatment Divisions, and the Safeguards Training Section.

2. Prepare separate IAEA draft guides based on existing material and material provided through Task C.31. Guides would be prepared to cover the principal topics for a generic mixed oxide facility.

   Guides should recommend systems, procedures, and relevant documentation that would satisfy the relevant obligations contained in Safeguards Agreements. Examples should be included, but it should be recognized that other means may also satisfy IAEA requirements. Recommendations should also be consistent with good industrial practice.

3. Prepare final guides with assistance of Task C.31 support, based on results of IAEA review.

b. Prepare SSAC guides for other facility types.

1. Based on a review of existing documents relevant to SSAC, together with discussions with IAEA staff and others, prepare an outline for a complete set of SSAC guideline documents and a projected time schedule and resources required for completing those guides.

TASK AREA C - System Studies

C.49 (cont'd)

Activities: (cont'd)

2. With mutual agreement of the IAEA Development, Operations, Information Treatment Divisions, and Safeguards Training Section prepare draft guidelines based on existing material and material provided through Member State support programs, collect comments and revise drafts.

Schedule and Milestones:

1. Start of Task - May 1982
2. Complete Task - April 1984

Funding:

To Date: $75,000

Estimated 1983, 1984: $115,000

TASK AREA C - System Studies

C.50

Subtask: Diversion Assumptions for High Power Research Reactors

Contractor: ORNL

Problem: The attractiveness for diversion of the nuclear materials consumed and produced in high power research reactors needs to be clearly specified in order that diversion scenarios can be identified and appropriate safeguards measures proposed and evaluated.

Objective: Provide assistance in the documentation of criteria and inspector observables related to undeclared plutonium production for high power research reactors including:

1. Criteria for undeclared plutonium production.
2. Necessary design information for implementation of these criteria.
3. Verification guidelines including neutron physics and heat transfer.
4. Safeguards measures to facilitate the detection of undeclared nuclear production at large research reactors.

Activities:

Phase I:

a. Prepare a work-plan and obtain IAEA concurrence.

b. For several types of large research reactors (MTR fuel, pool or tank type, with light water moderator and water or beryllium reflector):

   1. Define criteria which the Agency may use to assess the credibility of undeclared production of significant amounts of plutonium within or at the periphery of the active core along with quantitative estimates of production rates, (taking into account both physical possibility and the ability to operate the reactor safely); and

   2. Suggest methods (figures, graphs or tables) for making rough, quantitative, practical estimations of plutonium production for typical cases.

   The reactor types will be considered to have a nominal power of 25 MW (thermal).

c. Specify the necessary reactor design information for assessing the capabilities for making practical estimates of Pu production.

d. Suggest guidelines for verifications including neutron physics, heat transfer, and mechanical handling of radioactive components.

TASK AREA C - System Studies

C.50 (cont'd)

Activities: (cont'd)

Phase I: (cont'd)

e. Submit draft report for IAEA review.

f. Prepare final report.

Phase II:

Assist IAEA in determining the clandestine production potential for Pu or U-233 in 6-10 large research reactors under IAEA safeguards on the basis of agreed data. The contractor will identify the necessary data to be used for calculations and calculate reactor operating conditions and fuel usage necessary to produce one or more significant quantities of plutonium per year based on the available data.

Schedule and Milestones:

Phase I:

1. Start Task - July 1982
2. Complete (a) - August 1982
3. Complete (b-e) - December 1982
4. Complete (f) - March 1983

Phase II:

TBD

Funding:

To Date: Phase I: $60,000

Phase II: TBD

TASK AREA C - System Studies

C.51

Subtask: Use of Safeguards Effectiveness Assessment Methodology Data

Contractor: Decision Science Consortium

Problem: The IAEA Safeguards Effectiveness Assessment Methodology (SEAM) needs to be modified in accordance with the Advisory Group's recommendation. IAEA needs explicit procedures suitable for implementation by IAEA staff. Development is particularly needed for the use of SEAM data by SES.

Objective: 1) Assist the IAEA to modify proposed measures of effectiveness to be incorporated in the SEAM in accordance with the Advisory Group's recommendations.

2) Bring the methodology to the point where it can be implemented routinely by IAEA staff.

Activities:

Phase I:

a. Provide a detailed work plan.

b. Develop methods for formulating measures of effectiveness to be incorporated in SEAM that are suitable for any type of safeguarded facilities. These methods will focus on IAEA/SES uses of the results of SEAM and include the development or revision of aggregate measures to support SES uses. Review results with IAEA. Methods will be developed for light water reactors and differences for bulk handling facilities will be investigated.

1. Develop methods for evaluating the acceptability of safeguards coverage and seriousness of vulnerabilities.
2. Develop methods to aid in the choice of safeguards actions.
3. Develop methods to support resource allocations.
4. Develop methods for communicating the results of safeguards activities.
5. Develop methods for random selection of inspection activities.
6. Explore the need to introduce modifications in the aggregate measure.

c. Perform preliminary assessment of parameters of aggregate measures appropriate for the SES uses of the SEAM. Review results with IAEA.

TASK AREA C - System Studies

C.51 (cont'd)

Activities: (cont'd)

Phase I: (cont'd)

d. Illustrate use of the formulated method in a trial application for the LWR SEAM study. Review results with the IAEA. Illustration to include detailed, explicit procedures with examples in a form suitable for implementation by IAEA staff. Show what the decision aids developed for activity (b) uses would indicate in the trial application to actual inspection data.

e. Provide report on feasibility. Evaluate the soundness of the methods developed. Include evaluations of the appropriateness of the method for allocating inspection resources; performing design, implementation, and performance assessments, and communicating, as recommended by the AG. Evaluate the degree to which the methods developed meet the requirements of the Agency for the uses identified in activity (b).

f. Provide topical and final reports.

Phase II:

a. Demonstrate the application (activities to be determined).

Schedule and Milestones:

1. Start Phase I of Task - May 1982
2. Complete (a) - May 1982
3. Provide monthly status letters (5) - May/September 1982
4. Provide report on feasibility (b-e) - September 1982
5. Provide topical report(s) and final report - October 1982
6. Phase II - TBD

Funding:

To Date: Phase I: $60,000

Phase II: TBD

ACTIVE TASKS

TASK AREA
"D"

INFORMATION PROCESSING AND EVALUATION

TASK AREA D - Information Processing and Evaluation

The information supplied by Member States to the IAEA on movement of nuclear material is collated and analyzed in a computer-based information system. The product of these tasks will be various types of assistance and support to the Division of Safeguards Information Treatment (SIT). SIT currently maintains and processes incoming reports from Member States with the existing safeguards information system, and at the same time is in the process of implementing components of an advanced safeguards information system to meet the needs of the expanded activities of the IAEA. The nature of the support at this time is in the areas of computer peripheral hardware, software, personnel for assignments in SIT, and studies or evaluations.

In the area of data evaluation the inspection staff has encountered numerous problems of implementation which impinge on their ability to accomplish their jobs. These problems require expert assistance on a case-by-case basis, and direct interaction between the inspection staff and scientific specialists from the United States. Solving problems in these cases ultimatelydetermine the success of an inspection.

Also in the data evaluation area special implementation related tasks provide assistance to the Section for Data Evaluation Services and for the Safeguards Evaluation Section.

In assisting the Section for Data Evaluation, emphasis is placed on current implementation to meet the immediate needs of the Divisions of Operations. Procedures developed are tested by the Regional Operations Sections for simplicity and ease of application.

The Safeguards Evaluation Section is responsible for preparation of the annual Safeguards Implementation Report (SIR). The emphasis being on implementation using the inspection data, results and conclusions that are actually available in a given time period, and formulating conclusions on safeguards effectiveness from the real data. Development efforts continue on improvement of formats for recording inspection results and for inspection reports.

TASK AREA D - Information Processing and Evaluation

D.26

Subtask: Software Support for the Field Computer System

Contractor: BNL/ISPO

Problem: 1. The IAEA is developing a field computer capability consisting of a Headquarter's based computer system and transportable computers which accompany the inspectors into the field. A versatile software system must be developed to implement these functions.

2. An experienced data processing expert is needed to assist in the checkout of and transition to the advanced safeguards information system and to assist in the further development of the system to process inspection and other types of data and to develop application programs for the new system.

Objective: Provide a cost-free expert to serve on the IAEA staff for a period of three years.

Activities:

Phase I: (Problem #1)

a. Define specific field applications in detail with the purpose of 1) establishing requirements for the field computer, 2) establishing program flow to enable fast, well-organized writing of software.

b. Recommend the minimum and maximum field computer requirements for each application defined, e.g., data set size precision required on mathematics, special features required (e.g. graphics, screen displays), data link with Headquarters.

c. Write the programs and debug and test the programs using actual inspection data.

d. Issue program for field use. This would include writing a user's manual copying programs to media used on the field computer.

e. Following field tests, revise software based on field experience.

f. Participate in the documentation of software and inspection data processing procedures.

g. Participate in design of requirements for storage and transfer of field data to the Headquarters system so that it can be further processed on the IBM terminals at the end of material balance periods for preparation of inspection statements.

TASK AREA D - Information Processing and Evaluation

D.26 (cont'd)

Activities: (cont'd)

Phase II: (Problem #2)

Expert will continue the staff assignment of E. Kehl, Task D.29.

Schedule and Milestones:

1. Selection and approval of expert - November 1980
2. Begin appointment to IAEA - January 1981
3. Complete Phase I - May 1982
4. Complete Phase II - January 1984

Funding:

To Date: $85,000

Estimated 1983: $45,000

TASK AREA D - Information Processing and Evaluation

D.29

Subtask: Cost-Free Experts - Analysts/Programmers (3)

Contractor: BNL/ISPO

Problem: Experienced data processing experts are needed to assist in the checkout of and transition to the advanced safeguards information system and to assist in the further development of the system to process inspection and other types of data and to develop application programs for the new system.

Objective: Supply the required cost-free ADP experts (3 analyst/programmers to serve on the IAEA staff for a period of one to three years (extension of Tasks D.19 and D.25).

Activities: Experts will continue the staff assignments of E. Stone, D. Alspaugh, and B. Aspaugh.

Schedule and Milestones:

1. Selection and approval of experts - March 1980
2. Begin appointment to IAEA - March 1980, June 1980, July 1980
3. End appointment of A. Caldwell - June 1981
4. Extend appointment of Kehl to - July 1982
5. Extend appointment of Kaplan to - March 1983

Funding:

To Date: $330,000

Estimated 1983: $20,000

TASK AREA D - Information Processing and Evaluation

D.35

Subtask: Establish ICT Procedures for Use by Inspectors at Reprocessing Facilities Under Safeguards

Contractor: BNL/ISPO

Problem:

1. Isotopic correlation techniques (ICT) are used by the IAEA in verifying Pu and U inputs to reprocessing plants. A straightforward and clear set of procedures for applying ICT to input accountability is needed. Inspection requirements need to be specified.
2. IAEA inspectors need the capability to systematically collect data, evaluate data, and to report on the results of IAEA inspections.

Objective: Provide a cost-free expert to serve on the IAEA staff for a period of three years.

Activities:

Phase I:

1. Define objectives, raw data requirements, outline approach and design of software.
2. Develop Software for Data Input/Manipulation/Output for Field Version.
3. Direct and Assist in Near Term Development of Headquarters (IBM) Version in Order to Generate Correlations from the Historical Data Bank for Use in the Field and for Post Campaign Evaluations.
4. Prepare Training Package for Presentation to Inspectors/DES Analysts.
5. Provide Direct Support to Operations in the Application of ICT Software and Procedures.
6. Direct and Assist in the Implementation of French Approach for Generation of Correlations from Validated Reactor Burnup Calculations.
7. Document ICT Software and Procedures.

TASK AREA D - Information Processing a

D.35 (cont'd)

Phase II:

1. Work with the Task D.41 cost-free expert to provide the functional specification basis for an efficient, systematic approach to inspection preparation, data handling, data analysis and reporting in preparation for a working system design.

Schedule and Milestones:

1. Selection and approval of expert - May 1980
2. Begin appointment to IAEA - August 1980
3. Complete Phase I ICT activities - August 1982
4. Start Phase II - September 1982
5. End appointment to IAEA - August 1983

Funding:

To Date: $170,000

Estimated 1983: $50,000

TASK AREA D - Information Processing and Evaluation

D.37

Subtask: Expert for Development of Methods for Evaluation of Inspection Data

Contractor: BNL/ISPO

Problem: IAEA needs a statistical expert for inspection data evaluation in direct support of operations and for the near term development and implementation of NDA instruments.

Objective: Provide a cost-free expert to serve on the IAEA staff for a period of three years.

Activities:

The expert should be experienced in applied statistics and computer programming and be able to use the Agency equipment after a brief introduction. Examples of activities include:

a. In connection with IAEA Instrument Implementation Plans, provide needed statistical input to the following program areas;

  - determination of appropriate mathematical models for instrument calibration
  - development of up-to-date curve fitting procedures for calibration
  - investigation of instrument-operator systems to identify potential error sources and estimate error component magnitudes
  - determination of operating conditions and procedures to provide acceptable measurement errors
  - development of standard calibration and measurement procedures
  - documentation of statistical results.

  These tasks will require good communications with operations and NDA experts at the Agency.

b. Continue the activities of building a unified library of NDA instrument data collection/data evaluation programs for small computer use in the field. Instruments currently envisioned for inclusion in the library are: HLNCC, SILENA (MCA), AWCC, SAM-2, and perhaps VDC.

TASK AREA D - Information Processing and Evaluation

D.37 (cont'd)

Activities: (cont'd)

c. Provide support in the development of an automated statistical analysis package for ICT applications at reprocessing plants (error propagation, tests of significance, regression analysis)

d. Provide statistical consultation and recommendations, as requested.

e. Develop practical evaluation procedures that enable rapid computer processing and analysis of inspection measurement data.

Schedule and Milestones:

1. Start of Task - February 1981
2. Extend contract for one year until - February 1983

Funding:

To Date: $142,000

TASK AREA D - Information Processing and Evaluation

D.38

Subtask: Expert for Developing Methods of Evaluation and Processing of Inspection Data

Contractor: BNL/ISPO

Problem: The IAEA requires a computer programming, statistical evaluation expert to assist in evaluating data from actual inspections.

Objective: Continue the work of Task D.31 by providing a cost-free expert to serve on the IAEA staff for a period of one year.

Activities:

a. Locate candidates with background and training to perform the following functions for the IAEA

   1. Analyze material balance data and develop evaluation methods for detecting irregularities in over-all fuel cycle transactions.

   2. Analyze inspection measurement data and develop practical evaluation procedures.

   3. Prepare special statistical evaluation procedures for timely processing of safeguards data by computer, with special emphasis on computer printouts that can be easily understood by nonstatisticians.

   4. Formulate the statistical basis for a measurement error data bank for each nuclear material - measurement method-material balance area combination under safeguards.

   5. Implement routine procedures and train selected IAEA personnel.

b. Provide Personal History Form and background information to U.S. Mission to support recommendation of a candidate to IAEA.

Schedule and Milestones:

1. Selection and approval of expert - April 1981
2. Begin appointment to IAEA - June 1981
3. End appointment to IAEA - June 1982

Funding:

To Date: $65,000

TASK AREA D - Information Processing and Evaluation

D.39

Subtask: Senior Expert in Evaluation of Safeguards

Contractor: BNL/ISPO

Problem: Expert assistance is needed in reviewing, planning and implementing improved methodologies for the evaluation of safeguards effectiveness.

Objective: Continue the work of Task F.17 by providing a cost-free expert to serve on the IAEA staff of the Safeguards Evaluation Section for a period of two years.

Activities:

a. Locate candidates with background and training to perform the following functions for the IAEA.

   1. Participate in the further development of the Safeguards Assessment Methodology. Assist in the preparation of guides and procedures for the implementation of the Safeguards Assessment Methodologies.

   2. Assist in the review, planning and preparation of guides for the inspector's examination of records and reports, in coordination with Task B.7.

   3. Assist in the development of methodologies and procedures for the SES review and evaluation of inspection reports and data.

   4. Devise and implement methods and techniques for assessing the objective, but perhaps non-quantitative, information from safeguards activities.

   5. Participate in the planning of the Safeguards Implementation Report and in special projects for improving its content and presentation.

b. Select best candidate and recommend to the Mission and IAEA.

Schedule and Milestones:

1. Selection and approval of expert - March 1981
2. Begin appointment to IAEA - October 1981
3. End appointment to IAEA - October 1983

Funding:

To Date: $100,000

Estimated 1983: $90,000

TASK AREA D - Information Processing and Evaluation

D.40

Subtask: Cost-Free Expert - Analyst/Programmer

Contractor: BNL/ISPO

Problem: An experienced data processing expert is needed to provide dedicated support to the Safeguards Evaluation Section with respect to computerized analyses and evaluation of safeguards data, particularly for the preparation and presentation of the Safeguards Implementation Report.

Objective: Supply a cost-free expert to serve on the IAEA staff for a period of two years. The expert should have experience in data processing to include analyses, design and implementation of computer programs. Experience in international safeguards would be desirable.

Activities:

a. Locate possible candidates with qualifications to fill this position.

b. Select best candidate and recommend to the U.S. Mission and IAEA.

Schedule and Milestones:

1. Selection and approval of experts - March 1981
2. Begin appointment to IAEA - August 1981
3. End appointment to IAEA - July 1983

Funding:

To Date: $70,000

Estimated 1983: $70,000

TASK AREA D - Information Processing and Evaluation

D.41

Subtask: Expert for Developing Methods for Evaluation and Processing of Inspection Data

Contractor: BNL/ISPO

Problem: TBD

Objective: TBD

Activities: TBD

Schedule and Milestones:

1. Selection and approval of expert - May 1982
2. Begin appointment to IAEA - September 1982
3. End appointment to IAEA - September 1984

Funding:

To Date: $40,000

Estimated 1983: $100,000

1984: $ 60,000

TASK AREA D - Information Processing and Evaluation

D.42

Subtask: Cost-Free Expert - Documentation and Training Officer

Contractor: BNL/ISPO

Problem: The use of the International Safeguards Information System (ISIS) has been extended to all levels of users in the Department of Safeguards. Particularly, recent development efforts have concentrated on decentralizing the operations in that end users are responsible for performing their own data processing functions in the use of sub-systems developed by the Information Division.

In order to insure the effective use of ISIS and its associated sub-systems, the IAEA requires an expert to assist in the documentation of and training in these areas.

Objective: Supply a cost-free expert to serve on the staff of the IAEA for a period of two years.

Activities: Locate candidates with background and training to perform the following functions for the IAEA.

1. Prepare manuals at the system, program and user level. Compile information from system designers and programers as a basis for writing these manuals.

2. Develop the content of approved courses for users of the Safeguards Information System in cooperation with the Safeguards Training Unit; lecture at such courses.

3. Supervise the maintenance of existing documentation. Ensure that modifications/enhancements to system/program modules are reflected in the relevant manuals/handbooks.

4. Act as Secretary for the Department of Safeguards Information System (ISIS) Coordination Meetings; prepare working papers and records.

Schedule and Milestones:

1. Selection and approval of expert - September 1982
2. Begin appointment to IAEA - October 1982
3. End appointment to IAEA - September 1984

Funding:

To Date: $30,000

Estimated 1983: $75,000
1984: $65,000

TASK AREA D - Information Processing and Evaluation

D.43

Subtask:	Expert for Development of Safeguards Evaluation Methodologies and Procedures
Problem:	There remain interrelationships between the various elements of the IAEA safeguards system and their contributions to systems effectiveness that are not fully understood. Continuing development work is needed to establish methodologies for analyzing and evaluating data generated by safeguards activities and to prepare specific procedures for evaluation of safeguards implementation.
Objective:	Provide a cost free expert to serve on the IAEA staff for a period of two years to provide support in establishing the technical and procedural bases for assessing safeguards effectiveness; in modifying existing analytical and evaluative techniques for problems arising in assessment of safeguards data; and in testing and implementing the procedures and techniques developed.

Activities:

a. Develop and adapt methodology for evaluation of effectiveness of inspection activities as actually implemented.

b. Define and document evaluative criteria and guidelines.

c. Develop detailed evaluation procedures, specify the information needed to implement them, and assis in their testing and implementation.

d. Develop methods for feedback of assessments and evaluations into inspection planning, development programs, and other types of corrective action.

Schedule and Milestones:

1. Selection and approval of expert - May 1982
2. Begin appointment to IAEA - September 1982
3. End appointment to IAEA - September 1984

Funding:

To Date:	$40,000
1983:	$60,000
1984:	$40,000

ACTIVE TASKS

TASK AREA
"E"

CONTAINMENT AND SURVEILLANCE

TASK AREA E - Containment and Surveillance

The use of Containment and Surveillance (C/S) devices in safeguards can serve, to the degree desired, both to improve the assurance that no diversion has taken place, and to reduce the need for continuous personnel involvement (i.e., most methods involve the use of unattended equipment). While equipment and methods for Containment and Surveillance have been extensively developed for many kinds of applications, primarily for non-nuclear uses, the adaptation to IAEA safeguards has not been undertaken for specific safeguards applications.

This Task area is directed at identifying and providing new possibilities in safeguards methods which can enhance the application of nuclear safeguards. The nature of the support is primarily the provision of tamper-resistant hardware in the areas of surveillance systems, seals, sensors, monitors, and other types of C/S equipment.

While most of these items use state-of-the-art technology, some new design and development effort has been undertaken. Other tasks identified are primarily modifications of existing equipment. Many of the tasks will require provision of personnel to train IAEA inspectors in the use and maintenance of the equipment.

TASK AREA E - Containment and Surveillance

E.40

Subtask: Supply Portable Battery-Powered TV Surveillance Systems

Contractor: Sandia

Problem: The IAEA requires portable battery-powered TV surveillance systems for use in physical inventory verification and other safeguards activities.

Activities:

Phase I:

a. Based on requirements identified by IAEA modify the Class II unit provided to to IAEA under Task E.5. Deliver unit to IAEA.

b. Based on consultation with the IAEA, define a portable battery-powered TV surveillance system.

c. Construct, test, and evaluate, with IAEA participation, a Class III unit.

d. Deliver the Class III unit, an operator's manual and equipment manual, and a report of the test results to the IAEA.

Phase II:

a. Assist IAEA in the procurement of a suitable number of Class III units and operators and equipment manuals.

Schedule and Milestones:

Phase I:

1. Start task - March 1980
2. Complete (a) - August 1980
3. Complete (b) - TBD
4. Complete (c) - TBD
5. Complete (d) - TBD

Phase II:

1. Complete (a) - TBD

Funding:

		Sandia	ISPO
To Date:	Phase I -	$210,000	$6,000
	Phase II -	TBD	

TASK AREA E - Containment and Surveillance

E.45

Subtask: Integrated Monitoring System for Light Water Reactor Spent Fuel Storage Areas

Contractor: Sandia

Problem: Agency inspectors need the capability of augmenting optical surveillance with other types of monitors to avoid common mode failures that would result in loss of continuity of surveillance.

Objective: Develop and demonstrate an integrated monitoring system for use in LWR spent fuel storage areas.

Activities:

a. In consultation with the Agency, develop a work plan.

b. Develop design specifications and submit to IAEA for review and comment.

c. With IAEA concurrence, construct a Class II system.

d. Demonstrate to selected IAEA personnel the operation of the Class II system.

e. Based on activity (d), if required, make the necessary system modifications. Fabricate a Class III system for operational test and evaluation.

f. With Agency participation, install and evaluate the Class III system at a selected operating facility.

g. Provide IAEA with a final report of the evaluation.

Schedule and Milestones:

1. Start task - January 1980
2. Complete (a) - February 1980
3. Complete (b) - April 1980
4. Complete (c) - August 1980
5. Complete (d) - March 1981
6. Complete (e) - TBD
7. Complete (f) - TBD
8. Complete (g) - TBD

Funding:

	Sandia	ISPO
To Date:	$245,000	$7,000

TASK AREA E - Containment and Surveillance

E.46

Subtask: Cassette-Type Video Tape Recorder Evaluation

Contractor: Sandia

Problem: An evaluation of existing commercially available cassette-type VTR's is required in order to identify the relative reliability in potential Agency uses, as well as to potentially identify deficiences which may be corrected through future design changes.

Objective: Conduct a comprehensive evaluation of existing cassette-type VTR's and provide the Agency with a report of the findings as well as, if indicated, guidance regarding future design changes that would increase the overall reliability of VTR's.

Activities:

a. In consultation with the Agency, examine the most promising recording techniques for use in TV surveillance systems, and review available information on commercial models of cassette-type VTR's.

b. Provide to IAEA the information on VTR's surveyed that appear to meet IAEA requirements, and provide recommendations on the most promising VTR models.

c. With the concurrence of IAEA, select and purchase one or more of the most promising VTR's.

d. Prepare a detailed test plan for VTR's and submit to IAEA for review and comment.

e. Conduct the agreed upon tests with IAEA participation as required.

f. Prepare a final report on the findings of the test and evaluation, as well as, if indicated, guidance regarding recommended design changes.

Schedule and Milestones:

1. Start task - December 1980
2. Complete (a) - September 1981
3. Complete (b) - May 1982
4. Complete (c) - TBD
5. Complete (d) - TBD
6. Complete (e) - TBD
7. Complete (f) - TBD

Funding:

To Date: $25,000 To complete Activity (a) and (b) only.

TASK AREA E - Containment and Surveillance

E.50

Subtask: Improved Cerenkov Measurement System

Contractor: LANL

Problem: Inspectors need an improved system to provide quantitative measurements of Cerenkov light intensity.

Objective: Provide the Agency with a simple light integrating system that can be attached to a night vision device to provide a quantification of the light intensity.

Activities:

a. Define, in consultation with the Agency, a suitable technique for integrating the Cerenkov intensity when used in conjunction with the presently available night vision devices.

b. Design and fabricate the integrating system.

c. Demonstrate the use of the Class III measurement system at an irradiated fuel storage pond with participation of selected IAEA personnel.

d. Make any necessary modifications to the Class III system, deliver the unit to IAEA, train selected IAEA staff, and provide an equipment and user procedures manual.

Schedule and Milestones:

1. Start task - January 1980
2. Complete (a) - July 1980
3. Complete (b) - May 1981
4. Complete (c) - June 1982
5. Complete (d) - August 1982

Funding:

	LANL	ISPO
To Date:	$195,000	$5,000

TASK AREA E - Containment and Surveillance

E.54

Subtask: Program for Implementation of the Task E.25 Advanced TV Surveillance System

Contractor: Sandia

Problem: IAEA requires assistance in development and conduct of a program for placing the Task E.25 Sandia Advanced TV system (SAVIS) into routine use.

Objective: Assist IAEA by providing direct technical support in areas identified in the IAEA Implementation Program Plan.

Activities: Assist IAEA in conducting the following implementation plan:

Phase A: Test and Evaluation:

a. Development and, as necessary, conduct of a plan to field test and evaluate the system.

b. If required, repair and modification of the system.

c. Evaluation and documentation of the field test results.

d. Supply IAEA with three additional Class III systems for extended evaluation in the field.

e. If required, preparation and conduct of a seminar and demonstration for IAEA staff.

Phase B: Instrument Procurement, Procedures and Training:

a. Develop equipment specifications for procurement of the required number of systems.

b. Assist the Agency in procurement, including monitoring of quality control and acceptance tests.

c. Develop a program and manual for equipment maintenance. Identify test equipment and spare parts. Train maintenance staff.

d. Develop procedures for routine use of the instrument.

e. Test procedures in-the-field and modify if required.

f. Develop an inspectors training program and training materials to assist in proper use and operation of equipment.

TASK AREA E - Containment and Surveillance

E.54 (cont'd)

Schedule and Milestones:

Phase A:

1. Start Task - January 1981
2. Complete (a) - March 1981
3. Complete (b) - October 1981
4. Complete (c) - June 1982
5. Complete (d) - September 1982
6. Complete (e) - September 1982

Phase B:

1. Start Task - September 1981
2. Complete (a) - September 1982
3. Complete (b) - TBD
4. Complete (c) - April 1983
5. Complete (d) - April 1983
6. Complete (e) - TBD
7. Complete (f) - April 1983

Funding:

	Sandia	ISPO	
To Date:	$707,000	$50,000	To complete Phase A and Phase B.
Estimated 1983:	$155,000	$ -0-	

TASK AREA E - Containment and Surveillance

E.55

Subtask: Evaluation of RECOVER Monitoring System

Contractor: ISPO

Problem: The IAEA requires additional evaluation of RECOVER monitoring system.

Objective: Provide the Agency with support for field testing of RECOVER system.

Activities:

a. On the basis of experience obtained with the initial units developed by ACDA for the IAEA, consult with the Agency and provide support for appropriate field tests.

b. Support IAEA's long-term reliability testing of existing RECOVER:

- Assist in arranging for cooperation with personnel at facilities to be monitored.
- Provide funds for telephone charges resulting from RECOVER tests using a high calling rate to all sites over an extended (4-6 month) period.

c. Provide consultant support for analytical and experimental studies of ways in which use of the international dial-up telephone network for RECOVER communications can be made more efficient (and, consequently, more cost-effective). Areas of interest include:

- The communications channel itself (e.g.: obtain measuremnts of channel bit-error rates (BER) and relate those data to block retransmission rates).
- Hardware enhancements (e.g.: programmable automatic dialing equipment).
- Software enhancements (e.g.: modification of the communication protocol).

d. Study use of additional sensors (other than the Minolta camera, portal monitor and fiber-optic seal currently installed) and the desirability of monitoring additional parameters of the sensors presently in use.

e. Study possible additional capabilities of RECOVER and their potential impact on Nuclear Safeguards.

Schedule and Milestones:

1. Complete (a) - December 1982
2. Complete (b) - December 1982
3. Complete (c) - December 1982
4. Complete (d) - TBD
5. Complete (e) - TBD

TASK AREA E - Containment and Surveillance

E.55 (Cont'd)

Funding:

To Date: $60,000

TASK AREA E - Containment and Surveillance

E.56

Subtask: Professional Experienced in Remote Monitoring, Data Transmission and Surveillance Techniques.

Contractor: ISPO

Problem: Expert assistance is needed in the planning, testing and implementation of C/S techniques; and to delineate the role of RECOVER in the total safeguards information processing activities.

Objective: Supply a cost-free expert to serve on the IAEA staff for a period of two years to:

a. Participate in the development, testing and evaluation of containment and surveillance techniques for specific IAEA application.

b. Develop specifications and test programs to assure the provision of instruments and other equipment that will meet IAEA needs.

c. Continue the testing of RECOVER, collect data for system reliability analysis and make recommendations for possible design modifications.

d. Identify safeguards devices which could be remotely monitored; determine the modifications, if any, necessary to make the devices compatible with RECOVER and provide cost estimates.

e. Help establish a network architecture and cooperate in the writing of specifications of a system specification for a distributed data processing system incorporating the concepts of remote instrument monitoring as well as operator data entry.

f. Maintain records, prepare reports and make recommendations concerning the status of equipment relating to operating characteristics and the application of operating procedures.

Schedule and Milestones:

1. Selection of expert - July 1981
2. Begin Appointment - October 1981
3. Extend Appointment for one year until - September 1983

Funding:

To Date: $100,000

Estimated 1983: $60,000

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A.43	Active Assay of Highly Enriched Uranium in Unirradiated Fuel Assemblies or Containers			X		
A.44	Provision of Spiking Material for Isotope Dilution Mass Spectrometer Analysis			X		
A.45	Plutonium Assay Calorimetry			X		
A.46	Procurement of Two Intrinsic Germanium Coaxial Detectors with Amplifiers			X		
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A.48	In-Storage Pond Spent Fuel Burn-up Verification with Minimum Movement of Irradiated LWR Fuel Assemblies			X		
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A.54	Highly Portable, In-Place UF_6 Mass Determination			X		
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A.56	Measurement Procedures and Standard Reference Materials to Optimize Implementation of Resin Bead Techniques	X				9
A.57	Expert on Application of Resin Bead Technique				X	
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A.68	Supply of a Well-Type High Resolution Semiconductor Detector for Gamma Spectrometry			X		
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A.78	Demonstration and Application of Resin Bead Technology in the Analysis of Irradiated Fuel Solutions				X	
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B.11	Individualized Instruction			X		
B.12	Provision for Training Aids for Classroom Work			X		
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D.33	Assistance in Application of POTAS Developments			X		
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E.5	Design of a Battery Powered Portable TV Surveillance System			X		
E.6	Provision of Environment Resistant TV Surveillance Systems			X		
E.7	Study of Before-the-Lens Tamper Detection for Camera and TV Surveillance Systems			X		
E.8	Study and Possible Development of On-Line Interrogation of Surveillance and Sealing Systems			X		
E.9	Super 8 mm Surveillance Cameras				X	
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E.11	Development of Electronic Fiber Optic Seal System			X		
E.12	Improved Fiber Optic Seals			X		
E.13	Temporary Seals for Identification of Containers (Pressure Sensitive Tape)			X		
E.14	Sealing System for UF_6 Cylinders			X		
E.15	Sealing System for Storage Arrays of Spent HWR Fuel				X	
E.16	System for Sealing LWR Fuel Assemblies			X		
E.17	Intrusion/Motion Detection for Surveillance/Containment			X		
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E.20	Status Monitoring (Alternate to Optical Surveillance)			X		
E.21	Irradiated Fuel Monitor			X		
E.22	Solar Cell Gamma Detector			X		
E.23	Portal Monitors			X		
E.24	Reactor Power Monitor			X		
E.25	Development of a Reliable Advanced TV Surveillance System			X		
E.26	Expert to Perform Reliability Analysis and Recommend Maintenance Procedures for In-Field Video Surveillance System			X		
E.27	Design of a Semi-Automatic Scanner for Super 8 mm Movie Film			X		

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E.30	Expert in Containment and Surveillance			X		
E.31	Professional Experienced in Containment and Surveillance Techniques			X		
E.32	Mechanical Tamper-Indicating Reuseable Seal System				X	
E.33	Functional Evaluation of Film Cameras Suitable for Surveillance			X		
E.34	Hardware and Procedure to Prevent Before-the-Lens Tampering				X	
E.35	Underwater Identification of Fuel Assembly Numbers			X		
E.36	Optimum Design of Containers to Accommodate Seals			X		
E.37	Production of Electronic, Fiber Optic Seal Systems			X		
E.38	Development of an Improved Surface Type Seal				X	
E.39	TV Surveillance for Conditions of Low Light Level				X	
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E.49	Semi-Automatic Scanners for Super 8 mm Movie Film				X	
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E.52	Expert in Containment and Surveillance			X		
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F.3	Statistical Analysis of Analytical Data			X		
F.4	Sample Plan Calculation and Application			X		
F.5	Detection of Irregularities in Overall Fuel Cycle Transaction Reports			X		
F.6	Expert for Development of Methods of Evaluation of Inspection Data			X		
F.7	Cooperative Study with NRC at GE-Wilmington			X		
F.8	Review of Part F of Safeguards Technical Manual			X		
F.9	Development and Application of Isotopic Safeguards Techniques			X		
F.10	Senior Expert in Safeguards Implementation			X		
F.11	Expert for Designing and Documenting Procedures for Handling of Inspection Data			X		
F.12	Expert for Developing Methods of Evaluation and Processing of Inspection Data			X		
F.13	Application of Isotopic Safeguards Techniques at a Reprocessing Facility				X	
F.14	Senior Expert in Safeguards Implementation			X		
F.15	Senior Expert in Evaluation of Safeguards			X		
F.16	Volume III of Part F of Safeguards Technical Manual			X		
F.17	Senior Expert in Evaluation of Safeguards			X		
F.18	Technology Transfer of Developed Methodology for Applying the Kalman Filter			X		
F.19	Expert for Development of Methods of Evaluation for Safeguards Data			X		
F.20	Exchange of Experience with NRC Safeguards Inspectors			X		

ABBREVIATIONS & ACRONYMS

ACDA - Arms Control and Disarmament Agency
ADP - Automatic Data Processing
AECL - Atomic Energy of Canada Limited
AGNS - Allied General Nuclear Services
AmLi - Americium Lithium
ANL - Argonne National Laboratory, Illinois
ANCC - Active Neutron Coincidence Collar
AWCC - Active Well Coincidence Counter

Be - Beryllium
BNL - Brookhaven National Laboratory, New York
BPNL - Battelle Pacific Northwest Laboratory, Washington
BSAM - Brookhaven Survey Assay Meter
BWR - Boiling Water Reactor

CCD - Charge Coupled Device
CdTe - Cadmium Telluride
Cf - Californium
Ci - Curie
CRT - Cathode-Ray Tube
C/S - Containment and Surveillance

DIQ - Design Information Questionnaire
DOE - U.S. Department of Energy (successor to ERDA)

ED - Engineering Department
EG&G - Edgerton, Germhausen, & Greer - A Prime DOE Contractor
EURATOM - European Atomic Energy Community, Luxembourg
EUREX - Enriched Uranium Extraction

FBR - Fast Breeder Reactor(s)
FGR - Federal Republic of Germany

Ge - Germanium
GE - General Electric Company
GWK - Gessellschaft zur Wiederaufarbeitung von Kernbrennstoffen m.b.h.

He - Helium
HEDL - Hanford Engineering Development Laboratory
HEU - Highly Enriched Uranium
HLNCC - High Level Neutron Coincidence Counter
HTGR - High Temperature Gas-Cooled Reactor
HWR - Heavy Water Reactor

IAEA - International Atomic Energy Agency
ICAS - Introductory Course for Agency Safeguards
ICT - Isotopic Correlation Techniques
INEL - Idaho National Engineering Laboratory
INFCE - International Nuclear Fuel Cycle Evaluation
INFCIRC - Information Circular, IAEA Publication Nomenclature

ABBREVIATIONS & ACRONYMS (Cont'd)

ISIS - International Safeguards Information System
ISPO - International Safeguards Project Office
ISPRA - Joint Research Center, Ispra, Italy
IST - Isotopic Safeguards Techniques
ITV - Instructional Television

keV - Kilo Electron Volts
KMP - Key Measurement Point

LANL - Los Alamos National Laboratory
LEU - Low Enriched Uranium
LLNL - Lawrence Livermore National Laboratory
LMFBR - Liquid Metal Fast Breeder Reactor
LWR - Light Water Reactor

MBA - Material Balance Area
MCA - Multi-Channel Analyzer
MOUND - Monsanto Research Corporation Mound Facility
MTR - Material Test Reactor
MOFFF - Mixed Oxide Fuel Fabrication Facility
MOX - Mixed Uranium and Plutonium Oxide
MUF - Material Unaccounted For
MW - Megawatt

n/s - Neutron Per Second
NaI - Sodium Iodide
NBL - New Brunswick Laboratory, Argonne, Illinois
NBS - National Bureau of Standards, Department of Commerce
ND-6 - Mini MCA built by Nuclear Data Corp.
NDA - Non-Destructive Assay
NMMSS - Nuclear Materials Management and Safeguards Systems, DOE
NNC - National Nuclear Corporation
NPT - Non-Proliferation Treaty
NRC - Nuclear Regulatory Commission
NRX - Canadian Research Reactor
NWAL - Network of Analytical Laboratories

ORGDP - Oak Ridge Gaseous Diffusion Plant
ORNL - Oak Ridge National Laboratory
OSS - DOE Office of Safeguards and Security (successor to DSS)

PDM - Personnel Doorway Monitor
POTAS - U.S. Program of Technical Assistance to IAEA Safeguards
Pu - Plutonium
$PuNO_3$ - Plutonium Nitrate
PuO_2 - Plutonium Dioxide
PWR - Pressurized Water Reactor

RECOVER - Remote Continuous Verification
R&D - Research and Development

ABBREVIATIONS & ACRONYMS (Cont'd)

Sandia - Sandia National Laboratories
SAI - Science Applications Incorporated
SAL - Safeguards Analytical Laboratory, Seibersdorf, Austria
SALE - Safeguards Analytical Laboratory Evaluation
SAM - Stabilized Assay Meter
SDES - IAEA Section for Data Evaluation Services
SEAM - Safeguards Effectiveness Assessment Methodology
SES - IAEA Safeguards Evaluation Section
SIP - Safeguards Implementation Practices
SIT - IAEA Division of Safeguards Information Treatment
SNM - Special Nuclear Material
SRM - Standard Reference Material
SSAC - State's System of Accounting for and Control of Nuclear Material
SSIR - Special Safeguards Implementation Report
STS - IAEA Section for Technical Services

TBD - To Be Determined
TSO - Technical Support Organization
TASTEX - Tokai Advanced Safeguards Technology Exercise

U - Uranium
UCND - Union Carbide Nuclear Division
UF_6 - Uranium Hexafluoride
UNO_3 - Uranium Nitrate
UO_2 - Uranium Dioxide, "Brown Oxide"
U_3O_8 - Uranous Uranyl Oxide, "Black Oxide"
USIP - U.S. Initiative Program

VDC - Variable Deadtime Counter
VIC - Vienna International Center
VTR - Video Tape Recorder
WWER - PWR Fuel for Power Reactors Designed by USSR

New Technologies for Nonproliferation

Remote monitoring via a dial-a-safeguard RECOVER system is one of the technical aids for verification under development

When President Reagan visited New York to speak at the United Nations special session on disarmament on 17 June he called at the U.S. mission across U.N. plaza and swung through an exhibit on disarmament set up in the mission courtyard. Centerpiece of the exhibit is an array of electronic hardware with a potential for meeting some of the technical and political problems that beset nuclear nonproliferation efforts.

On display are the main elements of a system dubbed RECOVER (for REmote COntinuous VERification). The system is designed to bolster the safeguards regimen of the International Atomic Energy Agency (IAEA) in Vienna, which is aimed at deterring the diversion of weapons-usable nuclear materials. A year-long test of RECOVER at nuclear installations in seven countries* has recently been completed.

If successful, these efforts could lead to more reliance on remote methods of detecting diversion of critical nuclear materials. The technologies for which remote monitoring could be developed range from surveillance equipment in sensitive areas of nuclear facilities to radiation detectors designed to spot any loss of potential nuclear explosive from reprocessing facilities. In each case, the idea is to transmit data from these remote monitoring devices direct to IAEA's Vienna headquarters or to regional centers. The hope is that remote monitoring will provide more timely and accurate information than the current system, which relies on periodic on-site inspection by IAEA inspectors. Some countries, however, are likely to object that the new technologies will be too intrusive.

RECOVER, sponsored by the Arms Control and Disarmament Agency (ACDA), is only one of several research efforts by the United States and other countries to provide technical assistance to IAEA to strengthen its safeguards measures. The need for such efforts is seen as urgent by some observers who fear that the expected increase in the number of nuclear reactors operating worldwide and the possible spread of sensitive nuclear technology such as uranium enrichment and reprocessing plants could overload the IAEA safeguards program.

RECOVER had its origins during the Carter Administration. The system was designed by Atlantic Research Corporation, but when the contract for the prototype system was put out for bids the contract was won by TRW.

With the current system, a central unit in Vienna can be used to interrogate on-site equipment on a regular schedule or on demand over the international telephone system. Data from the remote units are stored and can be displayed on the central unit's screen. At the sites, sensors on surveillance equipment are connected to monitoring units that, in turn, feed information to a multiplexer capable of transmitting data to Vienna in encrypted form.

The sensors report on the operating status of surveillance and containment equipment supporting the safeguards program. In the recent test, for example, attention was centered on the standard dual cameras installed by IAEA to monitor reactor fuel loading and storage areas. Sensors on the cameras are capable of indicating, for example, whether film is intact, power in the emergency batteries is adequate, or the camera case has been tampered with. Other sensors were placed on fiber optic seals developed in the United States especially for the safeguards test. Sensors were also rigged on portal monitors developed by the Japanese; the monitors are capable of detecting motion or changes in radiation.

The current RECOVER system, still in the experimental stage, is designed for limited use at reactor sites. Broader applications for RECOVER are envisioned, however, in nuclear facilities and beyond. For example, use of a RECOVER type system in the verification of chemical warfare agreements is being considered, specifically, to monitor mothballed facilities capable of producing chemical warfare agents.

On his visit to New York the President spent about 5 minutes at the RECOVER exhibit getting a demonstration of its capabilities. The pause cannot be construed as a presidential laying on of hands for RECOVER, but, considering how presidential itineraries are made, it did signify Administration support for IAEA safeguards and interest in verification technology.

Verification has been an American priority in nuclear negotiations since World War II. At the U.N., Reagan devoted much of his speech to assessing Soviet actions in terms heard more often from American presidents on the campaign trail than on the U.N. podium, but, nonetheless, he called on the Soviets to cooperate with the United States in making meaningful progress on arms control, adding, "let me stress that for agreements to work, both sides must be able to verify compliance."

Verification measures in the nuclear nonproliferation field involve a set of problems different from those for strategic arms. In arms control negotiations, the Soviets have consistently resisted on-site inspections to monitor agreements. Soviet attitudes have been attributed usually to an ingrained disposition to secrecy in a closed society and a view that the presence of foreign inspectors on Soviet soil opens the way to espionage.

Alternatives to on-site inspection, such as satellite reconnaissance, seismic monitoring, and air-sampling techniques proved satisfactory to the two nuclear superpowers for verifying strategic arms agreements. These so-called "national technical means" of verification are inadequate, however, for nonproliferation verification. The most likely violations of nonproliferation safeguards would in-

> In the case of RECOVER and other technologies with safeguards potential, much technical ground remains to be covered before foolproof, cost-effective systems are available.

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*Australia, Britain, Bulgaria, Canada, West Germany, Japan, and the United States.

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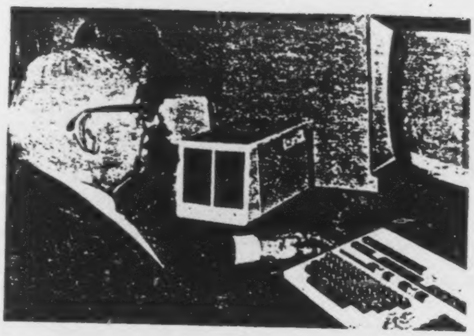
volve the diversion of quantities of nuclear material too small to be detected by such means. (The Soviets have recently encouraged partisans of nonproliferation policies by agreeing to place some of their nuclear facilities under safeguards.)



ACDA director Eugene V. Rostow gets hands-on demonstration of RECOVER.

A system like RECOVER, which has the capacity to keep tabs continuously on nuclear facilities and report anomalies that might indicate attempts at small scale diversion, is thought by its proponents to promise to enhance the power of safeguards to detect and deter diversion.

The IAEA safeguards program was created as a result of the Treaty on the Nonproliferation of Nuclear Weapons (NPT) of 1968. Signatory nations that did not have nuclear weapons accepted safeguards on their nuclear installations in exchange for assistance with development of peaceful uses for nuclear energy.

The present safeguards system is essentially a fuel-accounting system depending on IAEA inspectors making periodic visits to nuclear facilities to ascertain that the amount of fuel on hand accords with the records. The adequacy of the inspection system has been questioned, particularly in respect to providing timely warning of diversion. Criticism of the safeguards increased after the Israeli attack on Iraq's Osirak reactor in June of 1981. In the United States, questions centered mainly on lack of information obtainable from IAEA.

Last month, IAEA conceded that it could not certify that nuclear material was not being diverted in two nations, but said "it was reasonable to conclude" that such diversion had not occurred. The two nations were not identified by IAEA, but informed observers said that they were India and Pakistan.

As the number of nuclear facilities increases, IAEA is expected to encounter difficulties in finding sufficient funds and qualified inspectors to carry out the required inspections. Potentially, RECOVER could reduce costs and also limit the intrusiveness of inspections about which some countries complain.

An evaluation of RECOVER by a Brookhaven National Laboratory team gave qualified approval to the system. RECOVER was found to be cost-effective and technically adequate for use in reactor fuel storage areas and for monitoring the Canadian CANDU reactor and certain research reactors that afford more or less continuous access to fuel areas while the reactors are operating. The evaluation team found RECOVER less than cost-effective for pressurized water reactors (PWR's), the dominant commercial reactor type. The chief reason was that the danger of diversion from PWR's is greatest when the reactor is shut down for refueling, a time when inspectors are presumably present anyway.

Officials from ACDA and the six other countries that cooperated in the test met in Vienna late last month to review the experience gained in the test. Carl Thorne, the ACDA project officer for RECOVER who attended the meeting, says that the participants agreed that the test had been sufficiently promising to warrant development of a working version of the system. The next step will be to test improved interface hardware for the camera sensors. The current hardware produced too many anomalous signals during the test period. Those attending the meeting were optimistic about the prospects for achieving reliability, and IAEA officials are encouraging the project forward. Sensors are available to monitor additional safeguards functions more extensively; what remains is to make them remotely monitorable.

RECOVER, on which ACDA has spent a total of about $3 million, is only one of the technologies being worked on to back up IAEA safeguards. The Canadians are developing a closed-circuit television total monitoring system for their CANDU reactor. At Los Alamos National Laboratory a massive radiation detector is nearing completion. Called "Shuffler," it will be used in a new federal facility for reprocessing spent naval reactor fuel in Idaho Falls. Shuffler is probably too large and expensive to be used for commercial nuclear plant safeguards, but its technology for providing waste accountability and criticality measurement could prove useful in the IAEA context. Also at Los Alamos, work is going forward on a so-called Cherenkov counter, named after the Soviet scientist who observed the glow given off by fission products from nuclear fuel assemblies submerged in water in operating reactors. Both the counter and another device, a combination gamma ray and neutron detector being worked on at Los Alamos, promise to be of practical help to IAEA inspectors checking to see that fuel assemblies in use or in storage have not been tampered with. The Japanese portal monitor and a fiber optic seal devised in Germany are examples of relevant projects being carried on in other countries.

In the case of RECOVER and other technologies with safeguards potential, much technical ground remains to be covered before foolproof, cost-effective systems are available. Even when that occurs, formidable hurdles will remain. The countries involved in the RECOVER test are strongly committed to the safeguards idea. Other NPT signatory countries may object that installation of the new technology could lead to unnecessary and expensive plant shutdowns or might resist giving IAEA access to the kind of data that the new technology provides. IAEA and its partisans will, therefore, face a task of political persuasion if the technical problems are solved.

Is the new safeguards technology worth pursuing? Cornell professor Hans Bethe, a nuclear pioneer who has followed arms control and nonproliferation matters closely, says he is "impressed by the great sensitivity" of the radiation detectors being developed at Los Alamos and regards RECOVER as "also a useful system." Bethe goes on to say that "The point I want to emphasize is that IAEA should be putting emphasis on technical systems rather than on people. People, especially if they are nationals of a country involved, may lie. Technical systems do not. The technical systems are there. They should be used and IAEA given money for them—never mind the cost effectiveness."

—John Walsh

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UNCLASSIFIED CONTRACTOR REPORTS

NUREG/CR-0364	Simulating Barrier Penetration During Combat April 1980 Sandia Lab, Livermore SAND78-8235
NUREG/CR-0508	Security Communication Systems for Nuclear Fixed-Site Facilities July 1980 Y-12 Plant, Oak Ridge Y/DW-128
NUREG/CR-0543	Central Alarm Station and Secondary Alarm Station Planning Document June 1980 H. J. Wait Mason & Hanger - Silas Mason Co., Inc. MHSM-SD-7816
NUREG/CR-0641	SOURCE: A Convoy Ambush Simulation Code May 1980 Sandia Lab, Livermore SAND78-8034
NUREG/CR-0742	Review and Integration of Existing Literature Concerning Potential Social Impacts of Transportation of Radioactive Materials in Urban Areas July 1980 Rice Univ; Univ of Texas; Sandia Natl. Lab SAND78-7017
NUREG/CR-0744	Identification and Assessment of the Social Impacts of Transportation of Radioactive Materials in Urban Environments July 1980 Battelle Human Affairs; Sandia National Lab SAND79-7032, B-HARC-411-049
NUREG/CR-0773	Training and Qualifying Personnel for Performing Measurements for the Control and Accounting of Special Nuclear Material November 1980 Battelle Pacific Northwest Lab PNL-3020
NUREG/CR-0829	A Measurement Control Program for Nuclear Material Accounting June 1980 Battelle Pacific Northwest Lab PNL-3021
NUREG/CR-0830	Monitoring the Random Errors of Nuclear Material Measurements June 1980 R. J. Brouns; F. P. Roberts; J. A. Merrill Battelle Memorial Institute, Pacific Northwest Laboratory PNL-3022

NUREG/CR-0849 Vol. 1	Safeguards Material Control and Accounting Program: Quarterly Report October-December 1978 June 1980 Lawrence Livermore National Laboratory UCRL-52715-79-1
NUREG/CR-0849 Vol. 2	Safeguards Material Control and Accounting Program: Quarterly Report January-March 1979 June 1980 Lawrence Livermore National Lab UCRL-52715-79-2
NUREG/CR-0849 Vol. 2, No. 2	Safeguards Material Control and Accounting Program: Quarterly Report January-March 1980 October 1980 Lawrence Livermore National Lab UCRL-52715-80-2
NUREG/CR-0849 Vol. 3	Safeguards Material Control and Accounting Program; Quarterly Report April-June 1979 April 1980 Lawrence Livermore National Lab UCRL-52715-79-3
NUREG/CR-0849 Vol. 4	Safeguards Material Control and Accounting Program; Quarterly Report July-September 1979 May 1980 Lawrence Livermore National Lab UCRL-52715-79-4
NUREG/CR-0929	Sabres II: An Individual Resolution Small Arms Combat Simulation Model March 1980 Sandia Lab., Livermore SAND79-8249
NUREG/CR-0975	Nondestructive Assay Confirmatory Assessment Experiments: Mixed Oxide April 1980 Mound Facility, Miamisburg, OH MLM-2695
NUREG/CR-0976	User's Guide to Interactive FESEM January 1980 Sandia Lab, Albuquerque SAND79-1595
NUREG/CR-1017	Vulnerability Analysis of a Mixed-Oxide Plant May 1980 K. W. Foster; H. A. Woltermann Mound Facility, Miamisburg, OH MLM-2691

NUREG/CR-1048	Technical Safeguards Issues for Alternative Fuel Cycles January 1980 Brookhaven National Lab BNL-NUREG-51182
NUREG/CR-1118	The Distribution of Illegal Incident Characteristics: Cases of Bank Fraud and Embezzlement, Computer-Related Crime, and Insider Theft from Drug Manufacturers and Distributors June 1980 Lawrence Livermore National Lab UCRL-52742
NUREG/CR-1140 Vol. 1	Aggregated Systems Model of Nuclear Safeguards, Executive Summary, Vol. 1 Februrary 1980 Lawrence Livermore Lab UCRL-52712, Vol. 1
NUREG/CR-1140 Vol. 2	Aggregated Systems Model of Nuclear Safeguards, Vol. II Februrary 1980 Lawrence Livermore Lab UCRL-52712, Vol. 2
NUREG/CR-1142	Remote Response Mechanisms April 1980 Bernard Johnson, Inc., Houston Y/DS-99
NUREG/CR-1146	Safeguards Against Proliferation of Nuclear Materials. A Review and Bibliography March 1980 Oak Ridge National Lab ORNL/NUREG/NSIC-160
NUREG/CR-1166	COPS Model Estimates of LLEA Availability Near Selected Reactor Sites July 1980 Sandia Lab, Livermore SAND79-8261
NUREG/CR-1169 ES	Safeguards Vulnerability Analysis Program (SVAP). Executive Summary April 1980 Lawrence Livermore National Lab UCRL-52724
NUREG/CR-1169 Vol. 1	Safeguards Vulnerability Analysis Program (SVAP) Data-Gathering Handbook, Volume I April 1980 Lawrence Livermore National Lab UCRL-52731, Vol. 1

NUREG/CR-1169 Vol. 2	Safeguards Vulnerability Analysis Program (SVAP) Data-Gathering Handbook, Volume II April 1980 Lawrence Livermore National Lab UCRL-52731
NUREG/CR-1169 Vol. 3	Safeguards Vulnerability Analysis Program (SVAP) User's Manual, Volume 3 May 1980 Lawrence Livermore National Lab UCRL-52730
NUREG/CR-1178	Sabres II: Code Description and Users Manual March 1980 Sandia Lab, Livermore SAND79-8268
NUREG/CR-1192	Material Accounting as Required by the United States Nuclear Regulatory Commission: Capabilities and Vulnerabilities September 1980 Lawrence Livermore National Lab UCRL-52734
NUREG/CR-1198 Vol. 1 and 2	Design Guidance and Evaluation Methodology for Fixed Site Physical Protection Systems Volume 1 and 2 July 1980 Sandia National Lab, Albuquerque SAND79-2378/1 and 79-2378/2
NUREG/CR-1202	COPS - A Model for Estimating Local Law Enforcement Agent Availability March 1980 Sandia Lab, Livermore SAND78-8237
NUREG/CR-1214 Vol. 1	The Controllable Unit Approach to Material Control: Application to a High Through-put Mixed Oxide Process January 1980 Mound Facility, Miamisburg, OH MLM-NURG-2532, Vol. 1
NUREG/CR-1214 Vol. 2	The Controllable Unit Approach to Material Control: Application to a High Through-put Mixed Oxide Process January 1980 Mound Facility, Miamisburg, OH MLM-NURG-2532, Vol. 2
NUREG/CR-1226	POST: A Subroutine for Path Ordering of Sabotage Targets February 1980 Sandia Lab, Albuquerque SAND80-0058

NUREG/CR-1233 Vol. 1	The Structured Assessment Approach, Version 1, Analysis Package (Executive Summary) November 1980 Lawrence Livermore National Lab UCRL-52735, Vol. 1
NUREG/CR-1233 Vol. 2	The Structured Assessment Approach, Version 1, License Submittal Document Control and Format for Material Control and Accounting Assessment November 1980 Lawrence Livermore National Lab UCRL-52735, Vol. 2
NUREG/CR-1233 Vol. 3	The Structured Assessment Approach, Version 1, Applied Demonstration of Output Results November 1980 Lawrence Livermore National Lab UCRL-52735, Vol. 3
NUREG/CR-1234	The Insider Threat to Secure Facilities: Data Analysis June 1980 Lawrence Livermore National Lab UCRL-52744
NUREG/CR-1255	SKIRMISH and AMBUSH - Tactical Board Games for Development and Evaluation of Road Transit Physical Protection Systems March 1980 Sandia Lab, Livermore
NUREG/CR-1258 Vol. 1	Inspection Methods for Physical Protection Project: Quarterly Report, September-November 1979 March 1980 Lawrence Livermore National Lab UCID-18123-79-3
NUREG/CR-1258 Vol. 2	Inspection Methods for Physical Protection Project: Annual Report, March 1979 through February 1980 June 1980 Lawrence Livermore National Lab UCID-18123-79-4
NUREG/CR-1279	The Insider Threat to Secure Facilities -- A Synopsis of Nine Interviews March 1980 Lawrence Livermore Lab UCRL-52729
NUREG/CR-1283	Accounting Systems for Special Nuclear Material Control June 1980 Battelle Pacific Northwest Lab PNL-3265

NUREG/CR-1284	Methods for Determining and Controlling Bias in Nuclear Material Accounting Measurements June 1980 Battelle Pacific Northwest Lab PNL-3264
NUREG/CR-1310	Human Effects Aspects in Simulating Hostile Attacks Against Nuclear Facilities March 1980 Sandia Lab, Albuquerque SAND79-2237
NUREG/CR-1315	The Feasibility of Field Evaluation of Physical Protection Procedures May 1980 Lawrence Livermore National Lab UCRL-52740
NUREG/CR-1321	Final Report - Phase I. Systems Interaction Methodology Applications Program April 1980 Sandia National Lab, Albuquerque SAND80-0384
NUREG/CR-1327	Security Lighting - Planning Document for Nuclear Fixed Site Facilities April 1980 Mason & Hanger - Silas Mason, Lexington MHSM-SD 7911
NUREG/CR-1329	Physical Protection of Nuclear Facilities. Quarterly Progress Report, October-December 1979 May 1980 Sandia Lab, Albuquerque SAND80-0399
NUREG/CR-1338	Allocation of NRC Inspection Effort to Risk-Related Activities in Nuclear Power Plants April 1980 Sandia National Lab, Albuquerque SAND80-0361
NUREG/CR-1381	A Methodology for Evaluating Safeguards Capabilities for Licensed Nuclear Facilities - Final Report March 1980 Sandia National Lab, Albuquerque SAND80-7028
NUREG/CR-1385	Development of a "Good" Physical Protection Plan Capability 73.45(b) June 1980 Sandia National Lab, Albuquerque SAND80-7027

NUREG/CR-1445	Preparation of Working Reference Materials: Calcined Waste Recovery Products Containing Uranium or Plutonium August 1980 Los Alamos Scientific Laboratory LA-8348
NUREG/CR-1446	Preparation of Working Reference Materials: Uranium Dioxide May 1980 R. L. Hand; F. W. Spraktes; J. M. Baldwin Allied Chemical Corp.
NUREG/CR-1448	Physical Protection of Nuclear Facilities. Quarterly Progress Report, January-March 1980 July 1980 Sandia National Lab, Albuquerque SAND80-1006
NUREG/CR-1467	CAS-SAS Operational Work Station Design and Procedures November 1980 H. J. Wait; M. W. Manning Mason & Hanger - Silas Mason Co., Inc. MHSM-SD-7920
NUREG/CR-1468	Design Concepts for Independent Central Alarm Station and Secondary Alarm Station Intrusion Detection Systems November 1980 Mason & Hanger - Silas Mason, Lexington MHSM-SD 7919
NUREG/CR-1485 Vol. 1, No. 1	Safeguards Material Control and Accounting Program: Quarterly Report, October-December 1979 September 1980 Lawrence Livermore National Lab UCRL-52715-80-1
NUREG/CR-1487	Vital Area Analysis Using SETS May 1980 Sandia National Lab, Albuquerque SAND80-1095
NUREG/CR-1527	Enhancement of the Nuclear Materials Management and Safeguards System - Final Report August 1980 Boeing Computer Services, Vienna, VA
NUREG/CR-1528	Safeguards User's Manual for Nuclear Materials Management and Safeguards System - Final Report August 1980 Boeing Computer Services, Vienna, VA

NUREG/CR-1590	Evaluation Methodology for Fixed-Site Physical Protection Systems September 1980 Sandia National Lab, Albuquerque SAND80-0505
NUREG/CR-1591	A Combined SAFE/SNAP Approach to Safeguards Evaluation August 1980 Sandia National Lab, Albuquerque SAND80-0529
NUREG/CR-1604	Methodology Development for Risk Assessment for Fuel Processing July 1980 DuPont, Aiken, SC DPST-NUREG-78-4
NUREG/CR-1605	Modeling of Plant Protection and Control Systems for SSC June 1980 Brookhaven National Lab BNL-NUREG-51241
NUREG/CR-1610 Vol. 1, No. 1	Inspection Methods for Physical Protection Project: Quarterly Report, March-May 1980 August 1980 Lawrence Livermore National Lab UCID-18123-80-1
NUREG/CR-1614	Approaches to Acceptable Risk: A Critical Guide December 1980 Oak Ridge National Lab ORNL/Sub-7656/1
NUREG/CR-1619	Physical Protection of Nuclear Facilities. Quarterly Progress Report, April-June 1980 September 1980 Sandia National Lab, Albuquerque SAND80-1741
NUREG/CR-1670 Vol. 1	The Use of Process Monitoring Data for Nuclear Material Accounting: Volume 1 Summary Report October 1980 Battelle Pacific Northwest Lab PNL-3396
NUREG/CR-1676 Vol. 1	Using Advanced Process Monitoring to Improve Material Control September 1980 NUSAC, McLean, VA NUSAC-556

NUREG/CR-1758	Safeguards for High Level Waste Repositories - Final Report February 1979 - September 1980 October 1980 SAI01580-455LJ
NUREG/CR-1760	A Survey of Proposed Functional Requirements for a Disturbance Analysis and Surveillance System November 1980 Oak Ridge National Lab ORNL/NUREG/TM-396
NUREG/CR-1781	Assessment of Methods for Evaluating Adequacy of Physical Protection Systems November 1980 Chapman, L. D. Sandia Laboratories 8103020674 SAND80-2352 07781:235
NUREG/CR-1847	Standard Containers for SNM Storage, Transfer and Measurement Final Report April 1978 - August 1980 November 1980 K. R. Alvar; H. R. Lukens; N. A. Lurie IRT Corporation IRT-8179-019

1981
UNCLASSIFIED CONTRACTOR REPORTS

NUREG/CR-0602	Active Nondestructive Assay of Nuclear Materials. Principles and Applications Gozani, T. Science Applications, Inc. January 1981 8105260647. SAI-MLM-2585 08596:200
NUREG/CR-1245	User's Guide for SNAP Grant, F. H.: Chapman, L. D.; Engi, D. Sandia Labotatories July 1981 8110080550 SAND80-0315 10136:072
NUREG/CR-1246 V01	Safe Users Manual. Volume 1: Introduction to Safe Chapman, L. D.; Grady, L. M.; Engi, D; et al. Sandia Laboratories August 1981 8110300473 SAND79-2247/1 10433:300
NUREG/CR-1246 V02	Safe Users Manual. Method Description Chapman, L. D.; Grady, L. M, Engi, D; et al. Sandia Laboratories August 1981 8111160395 SAND79-2247/2 10672:095
NUREG/CR-1246 V03	Safe Users Manual. Volume 3: Example Edition Chapman, L. D.; Grady, L. M.; Engi, D.; et al. Sandia Laboratories August 1981 8112020866 SAND79-2247/3 11049:145
NUREG/CR-1345 V01	Nuclear Power Plant Design Concepts for Sabotage Protection Ericson, D. M.; Varnado, G. B. Sandia Laboratories, Albuquerque February 1981 8103100179 SAND80-0477/1 07866:328

NUREG/CR-1345 V02, Part 1 and Part 2	Nuclear Power Plant Design Concepts for Sabotage Control Ericson, D. M.; Varnado, G. B. Sandia Laboratories February 1981 8103030353 SAND80-0477/2 07804:075
NUREG/CR-1378 Rev. 1	Hardening Existing Strategic Special Nuclear Material Storage Facilities Garrett, A; MacMurdy, P. H. Army, Dept. of August 1981 8108270013 09509:268
NUREG/CR-1432	Brief Adversary Threat Loss Estimator (Batle) User's Guide Engi, D; Harlan, C. P. Sandia Laboratories May 1981 8107010486 SAND80-0952 08914:001
NUREG/CR-1574	Data Requirement Comparison Between the Fixed Site Upgarde Rule Guidance Compendium and the Structured Assessment Approach Licensee Submittal Document Parziale, A. A.; Sacks, I. J. Lawrence Livermore Laboratory January 1981 8102230396 UCID-18671 07738:105
NUREG/CR-1610 V01N02	Inspection Methods for Physical Protection Project Quarterly Report, June-August, 1980 Bowden, D. D.; Bradley, R. T.; Minichino, C.; et al. Lawrence Livermore Laboratory February 1981 8103040100 UCID-18123-80-2 07819:303
NUREG/CR-1610 V01N03	Inspection Methods for Physical Protection Project Quarterly Report, September-November 1980 Bowden, D. D.; Minichino, C.; Olson, A. W.; et al. Lawrence Livermore Laboratory February 1981 8103200357 08024:267
NUREG/CR-1771	Physical Protection of Nuclear Safeguards, Quarterly Progress Report for July-September 1980 Chapman, L. D. Sandia Laboratories February 1981 8111030316 SAND80-2428 10472:106

NUREG/CR-1785	Performance Evaluation of Loss Detection Schemes for Uranium Recovery Plants November 1981 Lawrence Livermore Laboratory UCRL-53012
NUREG/CR-1786	Maintainability Analysis Procedure (MAP) December 1981 Engi, D. Sandia National Laboratory SAND80-2497
NUREG/CR-1848 V01	Development and Evaluation of a Physical Protection Plan for 10 CFR 73.45 Capabilities (C), (D), and (F). Summary Guidance Compendium and Safeguards Upgrade Rule Evaluation (SURE) Methodology Testing Olascoaga, M. T.; Bennett, H. A.; Allensworth, J. Sandia Laboratories August 1981 8108270976 SAND80-2759 09515:335
NUREG/CR-1848 V02	Development and Evaluation of a Physical Protection Plan for 10 CFR 73.45 Capabilities (C), (D), and (F). Performance Capability (c). Olascoaga, M. T.; Bennett, H. A.; Allensworth, J. Sandia Laboratories August 1981 8109030316 SAND80-2759 V02 09632:019
NUREG/CR-1848 V03	Development and Evaluation of a Physical Protection Plan for 10 CFR 73.45 Capabilities (C), (D), and (F). Performance Capability (d). Olascoaga, M. T.; Bennett, H. A.; Allensworth, J. Sandia Laboratories August 1981 8109030314 SAND80-2759 V03 09631:185
NUREG/CR-1848 V04	Development and Evaluation of a Physical Protection Plan for 10 CFR 73.45 Capabilities (C), (D), and (F). Performance Capability (f). Olascoaga, M. T.; Bennett, H. A.; Allensworth, J. Sandia Laboratories August 1981 8109030205 SAND80-2759 V04 09630:252
NUREG/CR-1893	Application of Sandia Physical Protection Methods Pavlakos, C. J.; Chapman, L. D.; Grant, F. H.; et al. Sandia Laboratories June 1981 SAND81-0058 08959:237

NUREG/CR-1933	Physical Protection of Nuclear Facilities, Quarterly Progress Report, October-December 1980 Chapman, L. D. Sandia Laboratories June 1981 8108060366 SAND81-0256 09311:269
NUREG/CR-2026	Transeaver Specifications Overall Systems Design - Task 1 Final Report Peterson, B. R. Energy Incorporated April 1981 8111100003 10592:323
NUREG/CR-2031	A Method for Assessing the Performance of a Material Control and Accounting System at an Operating Nuclear Fuel Processing Facility Harris, L.; Ellwein, L. B. Science Applications, Inc. April 1981 8105110274 SAI01580-403LJ 08512:139
NUREG/CR-2041 V01	Evaluation of an Integrated Approach to Safeguards Regulations Al-Ayat, R. A.; Judd, B. R.; McCord, R. K. Lawrence Livermore Laboratory November 1981 8111170179 UCRL-53023 V01 10688:279
NUREG/CR-2075	Standards for Psychological Assessment of Nuclear Facility Personnel Frank, F. D.; Lindley, B. S.; Cohen, R. A. Assessment Designs, Inc. July 1981 8111100001 10592:081
NUREG/CR-2076	Behavioral Reliability Program for the Nuclear Industry Buchanan, J. C.; Davis, S. O.; Dunnette, M. D. Personnel Decisions, Inc. July 1981 8108180052 09410:001
NUREG/CR-2094 V01	Physical Protection of Nuclear Facilities, Quarterly Progress Report, January-March 1981 Chapman, L. D. Sandia Laboratories June 1981 8108270628 SAND81-0982/1 09514:070

NUREG/CR-2094 V02	Physical Protection of Nuclear Facilities, Quarterly Progress Report, April-June 1981 Chapman, L. D. Sandia Laboratories August 1981 8110300450 SAND81-0982/2 10416:334
NUREG/CR-2094 V03	Physical Protection of Nuclear Facilities, Quarterly Progress Report, July-September 1981 Chapman, L. D. Sandia Laboratories November 1981 8202050080 SAND81-0982/3 11830:001
NUREG/CR-2144	A Compendium of Computer Codes for Light Water Reactor Analysis Beinarz, P. P.; Prassinos, P. G.; Engi, D. Sandia Laboratories December 1981 8204020065 SAND81-1142 12511:261
NUREG/CR-2169	Transeaver/Transport-By-Sea-Verification Peterson, B. R.; Small, D. L.; Green, O. L.; et al. Energy Incorporated June 1981 8107020156 08921:001
NUREG/CR-2211	Modeling of Multiple Sequential Failures During Testing, Maintenance and Calibration Samanta, P. K.; Mitra, S. P. Brookhaven National Laboratory December 1981 8201110789 BNL-NUREG-51411 11556:271
NUREG/CR-2216	Institutional Issues Associated with Spent Fuel Storage Under Domestic and International Auspices O'Brien, J. N. Brookhaven National Laboratory September 1981 8201130452 BNL-NUREG-51413 11577:003
NUREG/CR-2217	Detection of Special Nuclear Materials at Portal Monitors and Locations and Recovery of Contraband Special Nuclear Materials: Legal and Technical Problems O'Brien, J. N. Brookhaven National Laboratory September 1981 8201130287 BNL-NUREG-51414 11570:036

NUREG/CR-2254
DRFT
A Procedure for Conducting a Human Reliability Analysis for Nuclear Power Plants
Bell, B. J.; Swain, A. D.
Sandia Laboratories
December 1981
8201250327
SAND81-1655 11669:156

Physical Protection Inspection Procedures
December 1981
Lawrence Livermore National Laboratory
Prepared for the Office of Inspection and Enforcement

1. 81100 Series: Power Reactors - Volume 1 and Volume 2
2. 81200 Series: SSNM Fixed Sites - Volume 1 and Volume 2
3. 81300 Series: Transportation - Volume 1 and Volume 2
4. 81400 Series: Special Nuclear Material of Moderate and Low Strategic Significance at Fixed Sites (MSNM and LSNM Fixed Sites)
5. 81500 Series: Appendix B to 10 CFR 73
6. 81600 Series: Appendix C to 10 CFR 73
7. 81700 Series: Licensee Implementing Procedures Evaluation

Reports Regarding International Safeguards Prepared for NRC/NMSS Since January 1980

Classification	Date	Title
U	2/81	Design Features to Facilitate IAEA Safeguards at Light Water Reactors
U	2/81	Design Features to Facilitate IAEA Safeguards at Reprocessing Plants
U	9/81	Design Features to Facilitate IAEA Safeguards at Mixed Oxide Fuel Fabrication Plants

1982 Thru June
UNCLASSIFIED CONTRACTOR REPORTS

NUREG/CR-1233 V04	The Structured Assessment Approach, Version 1, Computational Analysis Package Parziale, A. A.; Patenaude, C. J.; Renard, P.A.; et al. Lawrence Livermore Laboratory April 1982 8206100031 UCID-18146 13474:172
NUREG/CR-1245 R01	Corrections and Additions to User's Guide for SNAP (NUREG/CR-1245, SAND80-0315). Polito, J. Sandia Laboratories May 1982 8205190005 SAND82-7017 13186:259
NUREG/CR-1744 V01	Structured Assessment Approach (SAA) Input Package, Volume 1: Data-Gathering Handbook (Physical Security). Wahler, P. S. Lawrence Livermore Laboratory March 1982 8204160051 UCRL-53007 V01 12716:017
NUREG/CR-1744 V02	Structured Assessment Approach (SAA) Input Package, Volume 2: Data-Gathering Forms (Physical Security). Wahler, P. S. Lawrence Livermore Laboratory March 1982 8204210646 UCRL-53007 V02 12799:180
NUREG/CR-1744 V03	Structured Assessment Approach (SAA) Input Package, Volume 3: User's Manual (Physical Security). Orvis, W. J. Lawrence Livermore Laboratory March 1982 8204150580 UCRL-53007 V03 12687:009
NUREG/CR-2288	Computer Surety. Computer System Inspection Guidance Lawrence Livermore Laboratory - Taknekron Research, Inc. March 1982 8204020059 UCID-18975 12492:328
NUREG/CR-2297	Security Management Techniques and Evaluative Checklists for Security Force Effectiveness Final Report September 1980 - July 1981 Schurman, D. L.; Datesman, G. H.; Truitt, J. O. Applied Science Associates, Inc. April 1982 8204280027

NUREG/CR-2353
V02
Specification and Verification of Nuclear Power Plant Training Simulator Response Characteristics. Part II: Conclusions and Recommendations
Haas, P. M.; Kerlin, T. W.; Selby, D. L.; et al.
Oak Ridge National Laboratory
May 1982
8206090122
ORNL/TM-7985/P2 13456:185

NUREG/CR-2413
Survey of Remote Area Monitoring Systems at U.S. Light-Water-Cooled Power Reactors
Kathren, R. L.
Battelle Memorial Institute, Pacific Northwest Laboratory
April 1982
8204280021
PNL-4106 12876:285

NUREG/CR-2466
Statistical Sampling Plans for Prior Measurement Verification and Determination of the SNM Content of Inventories
March 1982
G. F. Piepel; R. L. Brouns
Pacific Northwest Laboratory
PNL-4057

NUREG/CR-2483
Evaluation of Simultaneous Testing Procedures for Nuclear Materials Control and Accounting
Bowen, W. M.
Battelle Memorial Institute, Pacific Northwest Laboratory
March 1982
8204150554
PNL-4085 12707:257

NUREG/CR-2492
Special Nuclear Material Self-Protection Criteria Investigation. Phases I and II
Koelling, J. J.; Barts, E. W.
Los Alamos Scientific Laboratory
January 1982
8202160078
LA-9213-MS 11945:068

NUREG/CR-2546
Reactor Safeguards Against Inside Sabotage
Bennett, H. A.
Sandia Laboratories
March 1982
8206290049
SAND82-0319 13661:165

NUREG/CR-2551
Rank Ordering of Vital Areas within Nuclear Power Plants
Richardson, J. M.
Sandia Laboratories
April 1982
8206250040 13628:168
SAND82-0332

NUREG/CR-2588
Security Officer Response Strategies (SECURORS).
Roundtree, S. L. K.
Sandia Laboratories
March 1982
8206240041
SAND82-0410 13609:299

NUREG/CR-2604
The SNAP Operating System (SOS) User's Guide
Sabuda, J. D.; Walker, J. L.; Polito, J.; et al.
Sandia Laboratories
March 1982
8205190010
SAND82-7018 13185:183

NUREG/CR-2605
The SNAP Operating System Reference Manual
Sabuda, J. D.; Polito, J.; Walker, J. L.
Sandia Laboratories
March 1982
8206100058
SAND82-7019 13467:137

CLASSIFIED SAFEGUARDS REPORTS

1980 TO DATE

1. UCID-19451
   Effectiveness Evaluation of Safeguards Using the Aggregated Systems
   Model: Nuclear Fuel Services, Inc., Irwin, Tennessee
   1981
   Lawrence Livermore

2. NUREG/CR-2693
   SAND82-7040
   Component Vulnerabilities and Component Level Design Changes for
   Protection Against Sabotage by an Insider
   March 1982 (at the printer as of 8/25/82)
   SAI for SANDIA

3. UCID-19144
   Application of the Safeguards Vulnerability Analysis Program (SVAP)
   to the Fuel Material Operation Facility at Nuclear Fuel Services
   Irwin, Tennessee
   October 1981
   Lawrence Livermore

4. UCID-19235
   Safeguards Vulnerability Assessments of the NMIS Building at INEL
   August 1981
   Lawrence Livermore

5. SVAP Data Gathering Handbook for Babcock and Wilcox Naval Nuclear
   Fuel Division (Background Report)
   May 1981
   Lawrence Livermore

6. SVAP Data Gathering Handbook for United Nuclear Corporation's Naval
   Products Facility (Background Report)
   May 1981
   Lawrence Livermore

7. SVAP Data Gathering Handbook for Fuel Material Operation Facility at
   Nuclear Fuel Services (Background Report)
   October 1981
   Lawrence Livermore

8. SAI-152-123-80-1
   Adversary Actions in the Nuclear Power Fuel Cycle: Reference
   Events and Their Consequences
   May 1981
   SAI for Brookhaven

   Vol. 1: Summary Report
   Vol. 2: Event Scenario and Release Source Terms - Appendix I
   Vol. 3: Detailed Listing of Event Consequences - Appendix II
   Vol. 4: Consequence Assessment Methodology - Appendices III through VII
   Vol. 5: Detonation of Nuclear Explosives
   Vol. 6: NUCRAC Consequence Estimation Code User's Manual

9. UCRL-52854
Value-Impact Analysis of Material Control and Accounting at
Vallecitos Nuclear Center
August 1980

10. MRC-R-564
Security Systems Performance Assessments Methodology
Phase 2, Vol. 1 and 2
April 1980

11. SAI-01580-451LJ
Evaluation of the Insider Threat to Light Water Reactor Sabotage -
Team Zoning and Area Zoning
Draft Paper No. 1
July 1980

12. SAI-01580-470LJ
Evaluation of the Insider Threat to Light Water Reactor Sabotage
Operation Zoning
Draft Paper No. 2
August 1980

13. SAI (Receipt No. 003160)
Light Water Reactor Operations Control Analysis - Volume I and II
July 25, 1980

14. Application of the Safeguards Vulnerability Analysis Program (SVAP)
to the United Nuclear Corporation Naval Products Facility at
Uncasville, Conn.
May 16, 1982 (DRAFT)
Lawrence Livermore (RES #002034)

15. Reprocessing of Nonpower Reactor Fuel for Clandestine Purposes
Exxon Nuclear Idaho Co., Inc.
December 22, 1980
BRD-148-80

16. Value-Impact Analysis of Nuclear Material Control and Accounting
Upgrade Alternatives
Lawrence Livermore Laboratories
November 1980
UCRL-53093

17. Evaluation of an Integrated Approach to Safeguards Regulations,
Volume 2
Lawrence Livermore Laboratories
March 1981
NUREG/CR-2041, Vol. 2
UCRL-53023, Vol. 2

18. Revised Selection of Shipped Radionuclides for Potential Safeguarding Against Malevolent Operators
Oak Ridge National Laboratory
March 1981
NUREG/CR-1766, ORNL/NUREG-69

19. Relative Hazards from Misuse of Byproduct Materials and Small Quantities of SNM Diverted by Malevolent Operators
Oak Ridge National Laboratory
March 1982
NUREG/CR-2203, ORNL-5793

20. Safeguards Analysis for Byproduct Materials and Small Quantities SNM
Oak Ridge National Laboratory
April 1982
NUREG/CR-2578, ORNL-5860

21. The Use of Process Monitoring Data for Nuclear Material Accounting, Vol. 3 Application to a High Enriched Uranium Fuel Fabrication Facility
PNL
August 1980
NUREG/CR-1670, PNL-3396, Vol. 3

22. Using Advanced Process Monitoring to Improve Material Control
NUSAC
September 1980
NUREG/CR-1676, NUSAC-556, Vol. 2

23. Feasibility and Cost/Benefit of Advanced Safeguards for Control of Nuclear Material In-Process
SAI
August 1980
NUREG/CR-1686, SAI 101580-343LJ, Vol. 2

24. Accounting Data Analysis Report for B&W Naval Nuclear Fuels Facility
NUSAC, Inc.
March 1982
NUSAC-691

25. Evaluation of Material Accounting Data Analysis at the Nuclear Fuel Services, Inc. Fuel Manufacturing Facility
NUSAC, Inc.
July 1981
NUSAC-646

CLassified Reports Regarding International Safeguards Prepared for NRC/NMSS Since January 1980

Classification	Date	Title
LOU	5/81	Implications of IAEA Technical Objectives

1978, 1979, 1980, AND 1981
DOE REPORTS PREPARED BY AGNS

FY 1978 SEQUENTIAL REPORTS ISSUED TO DOE UNDER CONTRACT NO. ET-78-C-09-1040

REPORT NUMBER	TITLE
AGNS/DOE-01-TR3.1-78/1	Separations Facility Baseline Description (Nonproprietary Section)
AGNS-1040-3.4-1	Topical Report on Product Form Evaluation Coconversion Alternatives
AGNS-1040-2.2-5	Nuclear Materials Control and Accounting System Evaluation Report - FY 1977 Cold Uranium Run
AGNS-1040-2.2-8	Description and Specifications of Components for a Computerized Nuclear Materials Control and Accounting System
AGNS-1040-2.2-9	Computerized Nuclear Materials Control and Accounting System Development Evaluation Report - 1978
AGNS-1040-2.4-10	Separations Facility Checkout Program Description and Evaluation
AGNS-1040-3.1-15	Evaluation of Alternatives for Processing Uranium-Based LWR Fuels
AGNS-1040-2.4-16	Checkout Procedure for 1978 Integrated Chemical Run
AGNS-1040-2.2-18	Conceptual Design of a Computerized Nuclear Materials Control and Accounting System - Preliminary
AGNS-1040-1.4-20	LWR Spent Fuel Storage
AGNS-1040-4.2-22	Flowsheets for Reprocessing Thorium-Based Fuels
AGNS-1040-2.4-23	1978 Integrated Uranium Run Plan
AGNS-1040-2.4-24	Description of the Laboratory Preparation to Support the Plant Preparation for the Integrated Safeguards System Evaluation Sub-Task 2.4
AGNS-1040-2.4-25	Plutonium Nitrate Storage and Loadout Checkout Program Report
AGNS-1040-2.2-26	Nuclear Materials Control and Accounting System Test Program FY 1978
AGNS-1040-5.2-27	The Requirements for Development of Evaluation Programs for BNFP Mothballing and Decommissioning
AGNS-1040-1.1-28	Operational Assessment of the General Electric IF-300 Rail Spent Fuel Cask

REPORT NUMBER	TITLE
AGNS-1040-1.1-29	Operational Assessment of the NLI 10/24 Spent Fuel Rail Cask
AGNS-1040-1.1-30	Operational Assessment of the NLI 1/2 Legal Weight Truck Spent Fuel Cask
AGNS-1040-1.1-31	Topical Report on the Operational Assessment of the Transnuclear TN-8/TN-9 Spent Fuel Cask
AGNS-1040-3.1-32	Engineering Evaluation of Alternatives for Processing Uranium Based Fuels
AGNS-1040-4.2-33	Purex Plant Modification for Reprocessing Thorium-Based Fuels
AGNS-1040-3.3-34	Storage and Handling of Wastes from Uranium Fuel Processing Alternatives
AGNS-1040-3.4-35	Definition of Products from Uranium Fuel Processing Alternatives
AGNS-1040-5.3-37	Technician Training
AGNS-1040-4.1-38	Technology Review of Thorium-Based Fuels
AGNS-1040-4.2-39	Thorium Fuel Alternatives Final Report
AGNS-1040-4.3-40	Flowsheet Development for Thorium-50% Uranium Laboratory Studies
AGNS-1040-4.4-41	Conversion of Products from a Thorium-Uranium Fuel Cycle
AGNS-1040-4.5-42	Comparison of Wastes from Uranium- and Thorium-Based Fuels
AGNS-1040-2.3-43	Process Radiation Monitoring System
AGNS-1040-2.3-44	Integration and Coordination of Safety-Operations-Safeguards
AGNS-1040-2.3-45	Advanced Physical Protection Systems for Nuclear Fuel Reprocessing Facilities
AGNS-1040-1.2-46	Simulated LWR Spent Fuel Receiving and Handling
AGNS-1040-1.3-47	Light-Water Reactor Spent Fuel Transportation Systems
AGNS-1040-1.5-48	The Conceptual Design of a Spent Fuel Cask Fleet Servicing Facility

REPORT NUMBER	TITLE
AGNS-1040-2.1-49	An Operational Evaluation of the Installed Physical Protection System at the BNFP (Confidential NSI Report)
AGNS-1040-2.2-50	Nuclear Materials Control and Accounting System Evaluation Report - FY 1978 Integrated Uranium Run
AGNS-1040-2.3-51	Development of Advanced Safeguards Systems for Nuclear Fuel Reprocessing (Confidential NSI Report)
AGNS-1040-2.3-52	On-Line Isotopic Concentration Monitor
AGNS-1040-2.3-53	Leached Hull Monitor
AGNS-1040-2.5-54	Analytical Laboratory Support Services for 1978 Uranium Run
AGNS-1040-3.6-55	Separations Facility FY 1978 Integrated Run Description and Evaluation
AGNS-1040-3.2-56	Adaptation of the Electropulse Column to Coprocessing Flowsheets
AGNS-1040-3.2-57	Evaluation of Trimetal Explosion-Bonded Couplings as Substitutes for Dissimilar Metal Flange/Gasket Joints
AGNS-1040-3.5-58	Preliminary Safety and Environmental Evaluation for Alternate Fuel Processes
AGNS-1040-3.7-59	Overall Siting Plan Baseline Description
AGNS-1040-5.1-60	Preventive and Corrective Maintenance Programs
AGNS-1040-2.3-62	Safeguards Literature Survey of the National Safeguards Research and Development Programs

FY 1979 SEQUENTIAL REPORTS ISSUED TO DOE UNDER CONTRACT NO. DE-AC09-78ET35900

REPORT NUMBER	TITLE
AGNS-35900-1.3-2	Life of Project Operating Expenses for Away-From-Reactor (AFR) Spent Fuel Storage Facility
AGNS-35900-3.1-5	Fuel Cycle Utilization Pu-238 as a Heat Spike
AGNS-35900-3.4-9	Conversion of Neptunium Nitrate to Neptunium Oxide
AGNS-35900-3.2-10	Flowsheets for Recovery of Neptunium from LWR Fuels
AGNS-35900-3.4-12	Wastes Generated by Neptunium Processing for the Heat Spike Fuel Cycle Concept
AGNS-35900-4.3-13	FY 1978 Preliminary Engineering Design Concept Analysis and Pu-238 Heat Spike Fuel Cycle Impacts (Classified Section 4.1.4.2 Confidential NSI)
AGNS-35900-2.1-15	Testing the Use of Canines for Personnel Explosives Screening and Other Physical Protection Related Activities
AGNS-35900-2.3-16	Criteria for Remotely Controlled Facility Use-Denial System (Confidential NSI)
AGNS-35900-2.3-17	Vehicle Access Portal Development and Testing
AGNS-35900-3.2-18	Processing Alternatives Evaluation for Neptunium Recovery
AGNS-35900-2.3-19	Evaluation of Protected Area Isolation Zone Intrusion Detection Equipment
AGNS-35900-4.1-20	Coprocessing Lists with Uranium on the Electropulse Column and Pilot Scale Pulse Columns
AGNS-35900-2.2-21	CNMCAS Conceptual Design -- Revised
AGNS-35900-2.2-22	Nuclear Materials Control and Accounting System Development -- FY 1979 Evaluation Report
AGNS-35900-2.2-23	In-Process Inventory Evaluation
AGNS-35900-2.2-24	Process Monitoring and Process Surveillance Demonstration Program
AGNS-35900-4.1-25	Engineering Evaluations of Wastes Handling and Storage Facilities

REPORT NUMBER	TITLE
AGNS-35900-4.3-27	Preliminary Conceptual Designs: High-DF Mixed Oxide Conversion Facility, Low-DF Oxide Conversion Facility, Heat Spike Mixed Oxide Conversion Facility, and Report of Neptunium Conversion Preliminary Engineering Design Concept
AGNS-35900-1.2-28	Shearing Tests Conducted at Allied-General Nuclear Services for the Consolidated Fuel Reprocessing Program
AGNS-35900-1.1-29	Spent Fuel Storage and Transportation: A Video Introduction to the Handling of Spent Fuel
AGNS-35900-3.3-30	Electrolytic Studies Pertaining to the 1B Electropulse Column
AGNS-35900-3.5-31	Identification of Economically Important Radwastes Variables
AGNS-35900-1.3-32	Converting Reprocessing Plant Fuel Receiving and Storage Area to an Away-From-Reactor (AFR) Storage Facility
AGNS-35900-3.3-33	Neptunium Recovery Laboratory Studies
AGNS-35900-4.4-34	Preliminary Safety and Environmental Evaluation for Alternate Fuel Processes
AGNS-35900-4.4-35	Preliminary Safety and Environmental Evaluation for the Heat Spike Alternative Process
AGNS-35900-5.2-36	Selective Waste Tank Systems Testing
AGNS-35900-1.5-37	Assistance to Department of Energy
AGNS-35900-5.3-40	Technician Training
AGNS-35900-2.4-42	Investigation of Alternate Analytical Techniques to Isotope Dilution Mass Spectrometry for Measurement of Uranium and Plutonium in Input Accountability Tanks
AGNS-35900-5.1-43	Preventive and Corrective Maintenance Programs
AGNS-35900-6.2-44	Separations Facility FY 1979 Integrated Uranium Run Description and Evaluation
AGNS-35900-1.2-45	Spent Fuel Disassembly and Canning Programs at the Barnwell Nuclear Fuel Plant (BNFP)
AGNS-35900-2.4-46	The Development and Modification of Analytical Chemistry Methods Required in the Separation of Nuclear Fuels

REPORT NUMBER	TITLE
AGNS-35900-1.3-47	Spent Fuel Disassembly: A Technique to Double the BNFP Storage Capacity
AGNS-35900-4.4-48	Addendum to Appendix B, AGNS-35900-4.4-34, Preliminary Safety and Environmental Evaluation for Alternate Fuel Processes
AGNS-35900-1.1-49	Advanced Cask Handling Studies
AGNS-35900-2.3-50	Safeguards Coordination Center
AGNS-35900-2.3-51	Access Control for Advanced Integrated Safeguards Systems
AGNS-35900-2.1-52	A Conceptual Security Organization to Support in Advanced Physical Protection Programs
AGNS-35900-2.4-54	Process Radiation Monitors
AGNS-35900-6.2-55	Analytical Laboratory Preparation and Support of the 1979 Integrated Process Run
AGNS-35900-4.5-56	Overall Siting Plan -- FY 1979 Update
AGNS-35900-2.3-57	Closed-Loop Control for Advanced Safeguards Systems
AGNS-35900-2.4-58	Plutonium Measurement Systems Using the On-Line Isotopic Concentration Monitor
AGNS-35900-1.4-59	Nuclear Spent Fuel Transportation Studies
AGNS-35900-5.2-60	Integrated Process Run Waste Processing and Disposal

FY 1981 SEQUENTIAL REPORTS ISSUED TO DOE UNDER CONTRACT NO. DE-AC09-78ET35900

REPORT NUMBER	TITLE
AGNS-35900-3.0-118	Utilization of the BNFP in the Breeder Reprocessing Program
AGNS-35900-CONF-119	Contactors for a Nuclear Reprocessing Plant Development of the Horizontal Pulsed Columns
AGNS-35900-CONF-120	An Automated On-Line Plutonium Concentration Monitor for Process Control and Safeguards Applications
AGNS-35900-CONF-121	Automated System for Controlling Authorization, Identification and Entry Into Fuel Facilities
AGNS-35900-2.3-122	Evaluation of Commercially Available Differential Pressure Transmitters for Use in a Nuclear Facility
AGNS-35900-2.3-123	High Precision Tank Volume Calibrations in a Reprocessing Facility - Techniques and Evaluations
AGNS-35900-2.5-124	Pilot-Scale Pulsed Columns, Aqueous Continuous Dual Process and Holdup Studies
AGNS-35900-JA-125	Demonstration of Near-Real-Time Accounting: The AGNS 1980 Mini-runs
AGNS-35900-CONF-126	Near-Real-Time Accounting in a Reprocessing Facility Using In-Process Inventory Estimation
AGNS-35900-2.2-127	Testing the Use of Canines for Personnel Explosives Screening
AGNS-35900-CONF-128	Access Control System Operation
AGNS-35900-CONF-129	Inspections - A Cost Effective Approach
AGNS-35900-CONF-130	First Cycle Studies of Coprocessing Flowsheets
AGNS-35900-CONF-131	In-Process Inventory Estimation in a Reprocessing Facility for Near-Real-Time Accounting
AGNS-35900-CONF-132	Development and Testing of a Near-Real-Time Accounting System for the Barnwell Reprocessing Facility
AGNS-35900-2.5-134	Transport of Simulated Dissolver Solids Via Air Lifts

REPORT NUMBER	TITLE
AGNS-35900-2.4-135	On-Line Density Measurement
AGNS-35900-2.4-136	The Determination of Free Acid in Plutonium (IV) Solutions
AGNS-35900-CONF-137	An Integrated Near-Real-Time Plutonium Inventory System for LWR Reprocessing Solutions
AGNS-35900-2.3-138	Development and Application of Algorithms to Predict Uranium Concentrations from Solution Density and Acidity Measurements
AGNS-35900-2.2-139	Advanced Development of Security Response Procedures for Nuclear Facilities (Confidential NSI)
AGNS-35900-2.4-140	OLICM Measurement
AGNS-35900-2.4-141	Passive Neutron Counter for Leached Hull Monitor
AGNS-35900-2.5-142	Mass Transfer and Near-Real-Time Inventory in Pulse Columns
AGNS-35900-1.3-143	The Use of Filler Materials to Aid Spent Nuclear Fuel Dry Storage
AGNS-35900-2.3-144	Automated On-Line Calibration of Differential Pressure Transmitters
AGNS-35900-CONF-145	Energy Dispersive X-Ray Fluorescence Analysis for On-Line Uranium Concentration Measurement
AGNS-35900-CONF-146	Determination of Free Acid in Plutonium (IV) Solutions - Thermometrically, Potentiometrically
AGNS-35900-2.3-147	Evaluation of In-House Versus Contract Computer Hardware Maintenance
AGNS-35900-2.3-148	Computerized Item Control and Accounting System Development and Demonstration
AGNS-35900-2.5-149	Coprocessing Purification Cycle Studies
AGNS-35900-2.4-150	Analytical Chemistry Methods Development and Quality Control Program
AGNS-35900-2.3-151	In-Process Inventory and Process Monitoring 1981 Program Report
AGNS-35900-2.1-152	APPS For a Nuclear Fuel Reprocessing Facility

REPORT NUMBER	TITLE
AGNS-35900-2.3-153	FY 1981 CNMCAS Development Program
AGNS-35900-2.3-154	Radio-Frequency Level-Measurement Device
AGNS-35900-2.4-155	Evaluation of an On-Line X-Ray Fluorescence Uranium Concentration Monitor
AGNS-35900-1.2-156	Techniques for Laser Processing, Assay and Examination of Spent Fuel
AGNS-35900-1.1-157	Operational Assessment of the FSV-1 (HTGR) Spent Fuel Shipping Cask in Alternate Modes
AGNS-35900-2.1-158	Development and Operation of Automated Access Control Systems
AGNS-35900-1.1-159	Operational Assessment of the Transnuclear TN-9 Truck Spent Fuel Shipping Cask
AGNS-35900-2.4-160	Analytical Chemistry Laboratory Computer Applications
AGNS-35900-1.4-161	Nuclear Transportation Studies Related to Use of the Barnwell Nuclear Fuel Plant
AGNS-35900-CONF-162	Process Information Displays from a Computerized NMC and Accounting System
AGNS-35900-CONF-163	Applications of Bulk Measurement Techniques for Near-Real-Time Accounting System at the BNFP
AGNS-35900-CONF-164	Can a Safeguards Accountancy System Really Detect an Unauthorized Removal?

FY 1980 SEQUENTIAL REPORTS ISSUED TO DOE UNDER CONTRACT NO. DE-AC09-78ET35900

REPORT NUMBER	TITLE
AGNS-35900-CONF-61	On-Line Monitoring of Plutonium in Mixed Uranium-Plutonium Solutions
AGNS-35900-JA-62	Fuel Cycle Utilizing Pu-238 as a "Heat Spike" for Proliferation Resistance
AGNS-35900-CONF-63	Spent Fuel Disassembly and Canning Programs at the BNFP
AGNS-35900-3.2-64	Liquid-Liquid System Contactors for Nuclear Fuel Reprocessing Plant
AGNS-35900-CONF-65	Automated Calibrations and Dynamic Corrections for Differential Pressure Transmitters
AGNS-35900-CONF-66	Safeguards Material Accountancy Inspections Via Telephone
AGNS-35900-CONF-67	Advanced Access Control System
AGNS-35900-CONF-68	Integration and Coordination of Safeguards with Operations and Safety
AGNS-35900-CONF-69	Coconversion of Mixed Plutonium-Uranium Oxides
AGNS-35900-CONF-70	Spent Fuel Dry Storage Concepts
AGNS-35900-CONF-71	Mixed Oxide Conversion Facility Alternative Conceptual Designs
AGNS-35900-CONF-72	Measuring Process Solutions in a Reprocessing Plant to 0.1%
AGNS-35900-CONF-73	Contactors Selection for a Nuclear Fuel Reprocessing Plant
AGNS-35900-2.4-74	Separations Plant Needle Sampler Modifications
AGNS-35900-CONF-75	High-Density Rack Concepts for AFR Fuel Storage Pools
AGNS-35900-2.3-76	Scope, Schedule, and Cost Estimate for Implementation of a CNMCAS System for a Reprocessing Facility
AGNS-35900-3.2-77	Design of Air Lift Systems for Transfers and Measurement of Radioactive Liquids

REPORT NUMBER	TITLE
AGNS-35900-2.1-78	Computer Controlled CCTV Alarm Assessment System Development
AGNS-35900-1.5-79	Scoping Studies of the Alternative Options for Defueling, Packaging, Shipping, and Disposing of TMI-2 Spent Fuel Core
AGNS-35900-3.3-80	Report on Engineering Evaluation of Processing Alternatives
AGNS-35900-CONF-81	Advanced Integrated Safeguards at BNFP
AGNS-35900-2.4-82	The Determination of Free Acid in Plutonium Solutions by Thermometric Titrations
AGNS-35900-2.4-83	Evaluation of an On-Line Alpha Monitor for Plutonium in a Uranium Product Organic Stream
AGNS-35900-2.2-84	Testing the Use of Canines for Personnel Explosives Screening
AGNS-35900-CONF-85	Potential for Meeting IAEA Safeguards Goals for Reprocessing
AGNS-35900-2.3-86	CNMCAS Expansion and Development 1980 Evaluation Report
AGNS-35900-2.3-87	In-Process Inventory -- 1980 Evaluation Report
AGNS-35900-2.3-88	Process Monitoring/Process Surveillance (PM/PS) Program Evaluation
AGNS-35900-2.3-89	RF Level Measurement Evaluation
AGNS-35900-2.3-90	Software Standards for the Computerized Nuclear Materials Control and Accounting System
AGNS-35900-2.1-91	SAFE Analysis of the BNFP (NSI Confidential Report)
AGNS-35900-2.4-92	Input and Product Uranium Measurement Systems Modification
AGNS-35900-3.1-93	Solvent Quality in the Purex Process
AGNS-35900-2.4-94	Near-Real-Time Inventory System for Plutonium Purification Cycle
AGNS-35900-3.1-95	First Cycle Evaluation of Alternatives Coprocessing Flowsheet

REPORT NUMBER	TITLE
AGNS-35900-1.3-96	Spent Fuel Dry Storage Studies at the Barnwell Nuclear Fuel Plant
AGNS-35900-2.4-97	Nondestructive Assay Techniques for Special Nuclear Material Measurements in Highly Radioactive Solutions
AGNS-35900-2.4-98	Plutonium Measurement Improvements by the Mass Spectrometric Technique
AGNS-35900-2.4-99	Evaluation of the Isotope Correlation Technique for Use in a Nuclear Fuel Reprocessing Plant
AGNS-35900-2.4-100	Analytical Chemistry Measurements Quality Control Program Improvements
AGNS-35900-2.4-101	A Nondestructive Assay Technique for Leached Hull Monitoring and Headend Operations
AGNS-35900-2.4-103	Application of Analytical Chemistry Methods to Remote or Containment Conditions
AGNS-35900-1.2-104	Spent Fuel Disassembly and Canning Programs at the Barnwell Nuclear Fuel Plant (BNFP)
AGNS-35900-2.1-105	Operational Evaluation of the Closed-Loop Control System
AGNS-35900-1.1-106	Cask Handling Equipment Standardization
AGNS-35900-2.4-107	On-Line Isotopic Concentration Monitors for Reprocessing Solutions
AGNS-35900-2.4-108	A Plutonium Safeguards Monitor for the Plutonium Nitrate Storage and Loadout Area Sample Glove Box
AGNS-35900-2.1-109	Automated Personnel Identification and Access Door Control
AGNS-35900-2.4-110	Analytical Chemistry Methods Development
AGNS-35900-3.1-111	Pilot-Scale Pulsed Columns Column Profile and Holdup Studies
AGNS-35900-2.1-112	Integration of Access Control with Safety-Operations-Safeguards
AGNS-35900-3.3-113	FY 1980 Update: Overall Siting Plan
AGNS-35900-2.1-114	Alarm Reporting and Assessment System and Development

REPORT NUMBER	TITLE
AGNS-35900-1.4-115	Transportation of Radioactive Material by Water
AGNS-35900-2.2-116	An Approach to the Development of Site Specific Response Procedures for Nuclear Facilities
AGNS-35900-2.1-117	Reporting Plant Operating Status to Outside Agencies

LISTING OF PUBLICATIONS ON SAFEGUARDS FUNDED BY ACDA

1. International Safeguards System Development

   AC8NC112

   International Safeguards Systems Development

   Battelle Memorial Inst.
   Human Affairs Research Center
   4000 N.E. 41st St.
   Seattle, Washington

2. Study of the Application of International Safeguards at the Portsmouth Gas Centrifuge Enrichment Plant

   AC8NA313

   A copy of this report was not available.

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   P.O. Box E
   Oak Ridge, TN

3. Initial Implementation and Demonstration of the Remote Continual Verification (RECOVER) System - MOD1-08/20/79; MOD2-02/28/80; MOD3-06/03/80; MOD4-09/15/80

   RECOVER Operational System Recommendations

   RECOVER Data Entry System Requirements

   RECOVER IAEA Test Program, Volume I Test Data Analysis & Results

   RECOVER Software Specification - Vol. I

   RECOVER RVU Software Maintenance Manual

   RECOVER Hardware Specification

   RECOVER Communications Manual

   Final documentation on RECOVER will be available in February of 1983.

AC8NC120

TRW INC
Defense & Space Systems Group (WO)
7600 Colshire Drive
McLean, Va.

4. Application of International Safeguards at Advanced Isotope Separation Facilities

AC8NA314

Title of Report "Requirements and Concepts" (Confidential)

DOE
(LASL)
Albuquerque Operations office
Albuquerque, NM

5. Further Development of an Advanced Fiber Optic Seal
MOD-1 09/27/79

AC8NC124

Design and Test of a Pre-Prototype Electronic, Fiber Optic Seal Monitor for use with the RECOVER System

Fiber-Lock Corporation

P.O. Box 263
Kensignton, MD

6. Support of IAEA/ACDA Research Agreement

AC9NA308 Funds Transferred to DOE - ISPO - IAEA for IAEA RECOVER support. No reports

DOE
Brookhaven Area Office
Brookhaven National Lab.
Upton,

7. Technical Evaluation of US Supplied IAEA Safeguards Equipment

AC9NX703 All Reports Confidential

ENSCO, Inc.
5408A Port Royal Rd
Springield, VA

8. Instant-Film Remote Diagnostic Surveillance System
AC9NC117

Reports not available at this time.

AERODYNE Research, Inc.
Crosby Drive
Bedford, MA

9. Comparison of ARC and FLC Optic Seal system

AC9NX703 All Reports Confidential

ENSCO, Inc.

10. Evaluation of Proposed Aerodyne Surveillance

AC9NX703 All Reports Confidential

Ensco, Inc.

11. Assessments of RECOVER System Security

AC9NX703 All Reports Confidential

ENSCO, Inc.

12. Local Reader for ARC and FLC Adaptors

AC9NX703 All Reports Confidential

ENSCO, Inc.

13. Assistance to IAEA Safeguards System Development

ACONC106

Assistance to IAEA Safeguards Systems Development Parts I and II

Battelle Memorial Inst.
Human Affairs Research Center
4000 N.E. 41st St.
Seattle, Washington

14. Development and Test of the TRANSEAVER System - Phase I

Transport-By-Sea-Verification (Executive Summary)

ACONC117

Energy Inc.
P.O. Box 736
Idaho Falls, Idaho

15. Component Parts for the RECOVER System

    AC1NC107 Equipment - No Report

    CHROMATICS, Inc.
    2558 Mt. Industrial Blvd.
    Tucker, Ga.

16. Seismic Data Transmission By Landlines

    ACOMA313

    Report not to be released to the public.

    Rome Air Development Center
    Air Force Systems Command
    Grifiss Air Force Base, New York

SANDIA NATIONAL LABORATORIES
ALBUQUERQUE, NEW MEXICO
SAFEGUARDS REPORTS AVAILABLE
CY 1980 TO JUNE 1982

TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
Sandia Technology, "The US Strategic Petroleum Reserve"	May 1982	unnumbered	U
Sandia Helicopter Acoustic Detector	May 1982	SAND81-0538	U
Perimeter Barriers and Cost-Effective Alternatives	March 1982	SAND82-0466	U
Video Motion Detection as Applied to Exterior Scenes	February 1982	SAND81-2255	U
Alternative Design Study on Personnel Portals for GCEP	January 1982	SAND81-2257	U
Igloo Access Denial Work	December 1981	unnumbered	C/NSI
Forcible Entry Testing of TSI Armor Core Doors and Upgrade Recommendations: Forcible Entry Testing of Insulgard S-100 Door	November 1981	unnumbered	C/NSI
Ported Coax Sensors	November 1981	SAND82-0015	U
A Field Test and Evaluation of Active Multibeam Exterior Infrared Intrusion Detection Sensors	November 1981	SAND81-2514	U

*U - Unclassified   C/NSI - Confidential National Security Information

TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
Q-Colors Logic Tree Analysis Program: A Guide for Users and Programmers	October 1981	SAND81-0955	U
Whiteshell Nuclear Research Establishment Perimeter Sensor Test Bed, Vol. 2 Final Report	September 1981	SAND81-0812/11	U
Sandia Technology, "Probing the Ocean Basins, The Subseabed Program"	September 1981	unnumbered	U
Hostage Countermeasures Program Plan	September 1981	unnumbered	U
Los Alamos TA-55 Perimeter Sensor Test Bed (Final Report)	September 1981	SAND81-1256	U
Sabotage Protection Considerations for Naval Petroleum Reserve No. 1	September 1981	SAND81-2118	C/NSI
Sandia Technology	July 1981	Volume 5, #4	U
Remote Alarm Processor	July 1981	SAND81-1601	U
PAT-2 (Plutonium Air-Transportable Model 2) Safety Analysis Report	July 1981	SAND81-0001	U
An Evaluation of Video Character Generators	June 1981	SAND80-0437	U

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*U - Unclassified C/NSI - Confidential National Security Information

TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
Conceptual Integrated Safeguards Study for a Plutonium-Handling Facility	August 1981	unnumbered	S/NSI
Guard Equipment Questionnaire: Final Report	August 1981	unnumbered	C/NSI
An Evaluation of Television Monitors for Alarm Display Systems	June 1981	SAND80-0532	U
Whiteshell Nuclear Research Establishment Perimeter Sensor Test Bed, Vol. 1. Interim Report	June 1981	SAND81-0812/1	U
Indirect Actuation of Solenoid Locking Devices	May 1981	SAND81-0596	U
Sandia Technology	May 1981	Volume 5, #3	U
Characteristics and Development of Electronic Fiber Optics Seal Mod 1	April 1981	SAND81-0677	U
Physiological Detection of Body Attitude: Feasibility Study and Sensor Development Final Report	April 1981	SAND81-7053	U
Engineering Evaluation of Israeli Aircraft Industries, Inc. (IAI) DTR-79CC TAUT-Wire Sensor Fences	March 1981	SAND81-0341	U

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C/NSI - Confidential National Security Information

TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
DOE Transportation and Weapons Protection Program Quarterly Report	June 1981	unnumbered	C/NSI
OSS Task - 1 Vault Door Program	July 1981	unnumbered	C/NSI
INEL Central Alarm and Response System	July 1981	unnumbered	C/NSI
Analyst Report for INEL Insider Study	June 1981	unnumbered	C
Adversary Evaluation of BPA Substations and Control Centers	June 1981	unnumbered	S
Sabotage Target Identification for the CRBRP	June 1981	unnumbered	S/NSI
Bonneville Power Administration A Summary of National Security Considerations	June 1981	SAND81-1186	C
SR Reactors Vulnerability Analysis	May 1981	SAND81-0891	S/NSI
SECURICOM: An Anti-Jam, Secure Message, Security Force Radio Communication System Design Feasibility Study	March 1981	SAND80-7049	U
Engineering Evaluation of Outdoor Infrared Intrusion Detectors	March 1981	SAND81-0039	U

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C/NSI - Confidential National Security Information
S/NSI - Secret National Security Information

TITLE	DATE	REPORT NUMBER	CLASSIFICATION*
SECURICOM: An Anti-Jam, Secure-Message, Security Force Radio Communication System Technical Summary	March 1981	SAND80-0347	U
SECURICOM: An Anti-Jam, Secure-Message, Security Force Radio Communication System Executive Summary	March 1981	SAND80-0346	U
Conceptual Designs for Safeguarding the CDS Liquid Metal Fast Breeder Reactor	February 1981	SAND81-0142	C/NSI
Airbone Threat Analysis for DOE Facilities: Phase I	February 1981	unnumbered	C/NSI
Characteristics of 7 Video Motion Detectors (VMD's) and Description of a Facility for VMD Evaluation	February 1981	SAND81-0268	U
Explosive Penetration of Concrete Walls	January 1981	SAND80-1942	U
An Improved Self-Energized Credential System	January 1981	SAND80-1746	U
An Unattended Material Inspection Portal for International Safeguards	January 1981	SAND80-1703	U

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TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
Transmittal of RS 3151/80/017, Integrated Safeguards Study for a Plutonium-Handling Facility	January 1981	unnumbered	S/NSI
Y-12 Perimeter Alarm Assessment System, Draft Design	January 1981	SAND80-2779	C/NSI
Integrated Safeguards Study of the LASL TA-55 Plutonium Facility	December 1980	SAND80-1136	S/NSI
A Typical Physical Protection System for An Away-From Reactor Spent Fuel Storage Facility	December 1980	unnumbered	C/NSI
Hot Experimental Facility Physical Protection System - A Review - Vol. II: Analysis	December 1980	unnumbered	C/NSI
Baseline Safeguards Analysis of the LASL TA-55 Plutonium Facility	December 1980	unnumbered	S/NSI
DOE Transportation and Weapons Protection Program Quarterly Report	December 1980	unnumbered	C/NSI
International Safeguards for a Light-Water Reactor Fuels Reprocessing Plant: Containment and Surveillance Concepts	December 1980	SAND80-0160	U

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C/NSI - Confidential National Security Information

TITLE	DATE	REPORT NUMBER	CLASSI* FICATION
Lock Handbook	November 1980	SAND78-0500	C/NSI
A Closed Loop Control System for a Plutonium Nitrate Storage and Loadout Area	November 1980	SAND80-2451	U
Hot Experimental Facility Physical Protection System -A Peer Review- Vol. 1: Recommendations	November 1980	SAND80-1469-1	U
Physical Protection Aspects of the Hanford 2736Z Upgrade Project	October 1980	unnumbered	C/NSI
Performance Estimates for Personnel Access Control Systems	October 1980	SAND80-0445	U
Baseline Safeguards Analysis of the TA-55 Plutonium Facility	October 1980	unnumbered	S/NSI
Path Analysis (PANL) User's Guide	September 1980	SAND80-1888	U
Evaluation of Passive Far Infrared Radiometric Techniques for Detection of Concealed Objects	September 1980	SAND80-1263	U
DOE Transportation and Weapons Protection Program Quarterly Report	September 1980	unnumbered	C/NSI

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TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
Development of an Unattended Personnel Portal for International Safeguards	September 1980	SAND80-1196	U
Barrier Technology: Vault Door Concept and Mockup	September 1980	SAND80-0998	U
Threat to BPA	September 1980	unnumbered	C/NSI
An Effectiveness Analysis of Physical Protection System Alternatives for the Fuels and Materials Examination Facility Vol. I	September 1980	unnumbered	C/NSI
Domestic Threat to the Strategic Petroleum Reserve	September 1980	unnumbered	C/NSI
Physical Penetration of Fire Insulated Vault Door	August 1980	unnumbered	C/NSI
An Analysis of the Design of CCTV Alarm Assessment Systems	August 1980	SAND80-1748	U
Preliminary Report on Security of DOE Nonnuclear Facilities	July 1980	unnumbered	C/NSI
Utility Line Safeguards	July 1980	SAND80-1511	U

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TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
DOE Nonnuclear Facilities Protection Concepts Project	July 1980	unnumbered	C/NSI
Savannah River Plutonium Storage Facility	June 1980	unnumbered	C/NSI
RATFOR: User's Guide	June 1980	SAND80-1171	U
Development of Laser-Based Techniques for Identification of Breached Nuclear Fuel Elements in Storage	June 1980	SAND80-1013	U
An Evaluation of Videodisc Recorders	March 1980	SAND80-0534	U
An Evaluation of Video Time Base Correctors	March 1980	SAND80-0428	OUO
An Evaluation of Video Field and Frame Synchronizers	March 1980	SAND80-0415	OUO
Evaluation of Perimeter Sensors for International Safeguards at Enrichment Plants: Interim Report	March 1980	SAND80-0093	U
An Effectiveness Analysis of Physical Protection Study Alternatives for the Fuels and Materials Examination Facility	March 1980	SAND80-0682	C/NSI

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TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
Containment and Surveillance Equipment Compendium	February 1980	SAND80-0002	U
A Digest of Containment and Surveillance Information	January 1980	SAND80-0001	U

LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS, NEW MEXICO
SAFEGUARDS REPORTS AVAILABLE
CY 1980 TO JUNE 1982

TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
Effectiveness Calculations of Portable High Purity Generous Inspection Strategy for International Safeguards at the Portsmouth, Ohio Gas Centrifuge Plant	1982	Q-2-82-308	S/RD
Inspection Strategies for Enrichment Plant Safeguards	1982	Q-2-82-306	S/RD
Los Alamos Plutonium Facility Implementation Support Project Report	May 1982	LA-9282-MS	U
SNM Monitor Applications: Diversion Safeguards for Emergency Exits and Detection of Undeclared Feed in Enrichment Plants	April 1982	LA-9310-MS	U
Test and Evaluation of the In-Line Plutonium Solution K-Absorption-Edge Densitometer at the Savannah River Plant	April 1982	LA-9124-MS	U
Nondestructive Verification and Assay Systems for Spent Fuels, Vol. I	April 1982	LA-9041	U

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TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
Nondestructive Verification and Assay Systems for Spent Fuels, Vol. II Technical Appendixes	April 1982	LA-9041	U
Multiplicity Sorter for Shift-Register Coincidence Electronics	February 1982	LA-9221-MS	U
A New 1-K PROM for the Coincidence Counter Electronics Package	February 1982	LA-9190-MS	U
Neutron Monitoring of Plutonium at the ZPPR Storage Vault	December 1981	LA-9108-MS	U
A Conceptual Design for a Receiving Station for the Nondestructive Assay of PuO_2 at the Fuels and Materials Examination Facility	November 1981	LA-9020-MS	U
An Evaluation of Sealed-Tube Neutron Generators for the Assay of Fresh LWR Fuel Assemblies	November 1981	LA-9103-MS	U
Neutron Measurement Techniques for the Nondestructive Analysis of Irradiated Fuel Assemblies	November 1981	LA-9002-MS	U

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TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
LIII-Edge Densitometer Operations Manual	October 1981	LA-8986-M	U
A Correction for Gamma-Ray Self-Attenuation in Regular Heterogenous Materials	September 1981	LA-8987-MS	U
Integrated Safeguards Systems: Design, Evaluation, & Application Interim Report	September 1981	unnumbered	U
A User's Guide to the Hydrogen Monitor	August 1981	LA-8957-MS	U
An Evaluation of the DYMAC Demonstration Program (Phase III Report)	August 1981	LA-8953-MS	U
Los Alamos Plutonium Facility Applied Systems Integration Project Status Report	August 1981	LA-9224-PR	U
Los Alamos Plutonium Facility Applied Systems Integration Project Status Report	August 1981	unnumbered	U
Description and Performance Characteristics for the Neutron Coincidence Collar for the Verification of Reactor Fuel Assemblies	August 1981	LA-8939-MS	U

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TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
Automated Controlled-Potential Coulometer for Plutonium Determination	May 1981	LA-8653	U
Materials Measurement and Accounting in an Operating Plutonium Conversation and Purification Process. Phase I: Process Modeling and Simulation	April 1981	LA-8809-MS	U
Test and Evaluation of the Dual-Range Coincidence Counter at the Savannah River Plant	April 1981	LA-8803-MS	U
Evaluation of Savannah River Plant Shuffler Calibration Standards	March 1981	LA-8793-MS	U
Irradiated Fuel Examination Using the Cerenkov Techniques	March 1981	LA-8767-MS	U
Spent-Fuel Composition: A Comparison of Predicted and Measured Data	March 1981	LA-8764-MS	U
Program Status Report Safeguards and Security Research and Development	February - July 1981	LA-9110-PR	U
Test Results for the FAST Facility Delayed Neutron Interrogator Source Transfer System	January 1981	LA-8684-MS	U

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TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
Safeguards in the Seventies - A Bibliography of LASL Safeguards R&D Publications 1970-1979	January 1981	LA-8663-MS	U
JB Line Modeling and Simulation	1981	SR-S-1729	S/RD
Conceptual Design for the Field Test and Evaluation of the Gas-Phase UF_6 Enrichment Meter	December 1980	LA-8657-MS	U
A Preliminary Report of Short-Term Materials Accounting at GCEP	December 1980	LA-8651-MS	U
International Training Course on Nuclear Materials Accountability for Safeguards Purposes, Proceedings Vol. I	December 1980	LA-8620-C	U
International Training Course on Nuclear Materials Accountability for Safeguards Purposes, Proceedings Vol. II	December 1980	LA-8620-C	U
Plutonium Isotopic Composition by Gamma-Ray Spectroscopy	November 1980	LA-8603-MS	U
Nuclear Safeguards Research and Development Program Status Report	October 1980 - January 1981	LA-8879-PR	U

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TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
The CMB-8 Material Balance System	August 1980	LA-8194-M	U
Nuclear Safeguards Research and Development Program Status Report	July - September 1980	LA-8590-PR	U
DYMAC Digital Electronic Balance	June 1980	LA-8313-M	U
^{242}Pu Isotopic Verification	May 1980	LA-8372-MS	U
Coprecal: Materials Accounting in the Modified Process	May 1980	LA-8358-MS	U
Materials Mangement in an Internationally Safeguarded Fuels Reprocessing Plant Vol. I	April 1980	LA-8042	U
Materials Management in an Internationally Safeguarded Fuels Reprocessing Plant Vol. II	April 1980	LA-8042	U
Materials Management in an Internationally Safeguarded Fuels Reprocessing Plant Vol. III	April 1980	LA-8042	U
Nuclear Safeguards Research and Development Program Status Report	April - June 1980	LA-8514-PR	U
Evaluation of In-Line Nondestructive Assay Systems	April - June 1980	LA-8545-PR	U

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TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
Shift-Register Coincidence Electronics System For Thermal Neutron Counters	April 1980	LA-8319-MS	U
Measurement of Uranium and Plutonium in Solid Waste by Passive Photon or Neutron Counting and Isotopic Neutron Source Interrogation	March 1980	LA-8294-MS	U
Savannah River Plant Californium-252 Shuffler Electronics Manual	March 1980	LA-8103-M	U
Evaluation of In-Line Nondestructive Assay Systems	January - March 1980	LA-8411-PR	U
Nuclear Safeguards Research and Development Program Status Report	January - March 1980	LA-8373-PR	U
A Plutonium Solution Assay System Based on High-Resolution Gamma-Ray Spectroscopy	January 1980	LA-8146-MS	U
Contribution to Safeguards Effectiveness Evaluation GCEP International Safeguards Evaluation Studies, Part II	1980	Q-1-80-506	S/RD

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TITLE	DATE	REPORT NUMBER	CLASSI-FICATION*
DYMAC Communications System	January 1980	LA-8182-M	U
Quantitative Evaluation of the Effectiveness of Six Neutron Detection Deployment Strategies at Detecting Clandestine HEU Production and/or Uranium Storage in the GCEP	1980	Q-1-80-651	S/RD
Los Alamos Science Reactor Safety	Summer/ Fall	Vol. 2 #2	U

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BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK
SAFEGUARDS REPORTS AVAILABLE
CY 1980 to JUNE 1982

TITLE	DATE	REPORT NUMBER	CLASSIFICATION*
An Assessment of the Application of IAEA Safeguards at U.S. Isotope Separation (AIS) Enrichment Facilities	February 1982	82-23	S/RD
Impacts of DOE Threat Guidance Order (5600) Upon the Richland Operations Office	September 1981	81-59	C/NSI
Summary of Principal Results and Recommendations Applying Various Safeguards Methodologies to Z	July 1981	81-56	C/NSI
Report on the U.S. Program of Technical Assistance to Safeguards of the International Atomic Energy Agency (POTAS)	May 1981	BNL 51440	U
Differences in DOE and NRC Safeguards and Security Requirements and Their Potential Impacts on Comparability of DOE and NRC Systems	March 1981	BNL-29272	U

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C/NSI - Confidential National Security Information

TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
Differences in DOE & NRC Safeguards & Security Requirements and Their Potential Impacts on Comparability of DOE and NRC Systems, Part II	December 1980	81-5	C/NSI
Application of the Minor-Isotope Safeguards Technique (MIST) For IAEA Safeguards at a Model Gaseous Diffusion Uranium Enrichment Facility	December 1980	81-4	C
A Review of Source Material Safeguards	July 1980	80-38	C
Adversary Actions in the Nuclear Power Fuel Cycle: Reference Events and Their Consequences, Vol. I: Summary Report	June 1980	80-43	C/NSI
Driver Fuel Fabrication	April 1980	80-25	C/NSI

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MISCELLANEOUS SAFEGUARDS REPORTS AVAILABLE CY 1980 TO JUNE 1982

TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
Controllable Unit Approach: An Application Manual	June 1982	MLM-2881	U
Energy and Technology Review, LLNL	June 1982	unnumbered	U
GRPAUT User's Guide	May 1982	MLM-2910	U
Design Considerations for an Integrated Safeguards System for Fuel Reprocessing Plants	May 1982	ENICO-1107	U
Optical Spectroscopic SNM Assay (OSS), Quarterly Report January - March 1982	May 1982	IS-4800	U
Feasibility Study Quarterly Report October 1981 - December 1981	March 1982	IS-4795	U
Progress Report for the Period October 1980 through September 1981	March 1982	NBL-304	U
Part-Support Studies for Diamond Machining Mirrors	February 1982	Y-2268	U
Precision Level/ Density Scanner Advanced Safeguards Systems Development for Chemical Processing Plants	January 1982	ENICO-1080	U

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TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
UCC-ND Enrichment Safeguards Program Quarterly Report October - December 1981	January 1982	K/OA-4708, Part 8	OUO
Recommendations to Modify the GAT Automatic In-Line UF_6 Sampling System for International Safeguards	December 1981	K/OA-5100	U
Progress Report for the Office of Safeguards and Security for FY 1981	November 1981	ORNL/TM-8097	U
Critical Experiments Supporting Underwater Storage of Tightly Packed Configurations of Spent Fuel Pins	November 1981	BAW-1645-4	U
An Experimental Investigation of Fluidized Bed Denitration at the Idaho Chemical Processing Plant	October 1981	ENICO-1089	U
Gamma Spectrometric Determination of Uranium-235 in Uranium Hexafluoride in 1S and 2S Cylinders	October 1981	K-2021, Supplement	U
Minutes of the Fourth Sale Program Participants Meeting July 1981	October 1981	unnumbered	U
An Automated Transportable Mass Spectrometer	September 1981	ENICO-1096	U

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TITLE	DATE	REPORT NUMBER	CLASSIFICATION*
Themohydraulic Analysis of BWR and PWR Spent Fuel Assemblies Contained Within Square Canisters	September 1981	PNL-3945	U
In-Plant Test Measurements for Spent Fuel Storage at Morris Operation Vol 2: Fuel Bundle Radiation Levels	September 1981	NEDG-24922-2	U
Development of Deterrence Strategies	September 1981	BDM/W-81-470-TR	U
The Quantitative Ion Exchange Separation of Plutonium from Impurities	September 1981	NBL-298	U
An Extended Work Plan for the Simultaneous Assay of Uranium and Plutonium, and their Isotopes, by Optical Emission Spectroscopy	August 1981	IS-4774	U
Licensing Schedule for Away-From-Reactor (AFR) Spent Fuel Storage Facilities	August 1981	DP-1582	U
The New Brunswick Laboratory Controlled-Potential Coulometric Method for the Determination of Plutonium	June 1981	NBL-299	U

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TITLE	DATE	REPORT NUMBER	CLASSI-* FICATION
Safeguards Analytical Laboratory Evaluation (SALE) 1980 Annual Report	June 1981	NBL-300	U
Final Report for FY 1980 - Advanced Safeguards Systems Development for Chemical Processing Plants	April 1981	ENICO-1079	U
Progress Report for the Period October 1979 through September 1980	April 1981	NBL-297	U
Security Clearance Criteria and Insider Motivations	April 1981	BHARC-400/81/004	U
Flexural Type Ultrasonic Liquid-In-Line Detectors with Multiplexing Electronics	February 1981	ENICO-1071	U
Safeguards Analytical Laboratory Evaluation (SALE)	November 1980	unnumbered	U
Safeguards Analytical Laboratory Evaluation (SALE)	September 1980	unnumbered	U
Potential Saboteurs to DOE Programs: Attributes and Inferences	September 1980	ATAR-1014.80	U
A Description of the Portsmouth Gas Centrifuge Enrichment Plant	August 1980	K/OA-4783	U

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TITLE	DATE	REPORT NUMBER	CLASSIFICATION*
The Dissolution of HTGR Triso Beads by the Alkali Fluoride Fusion Method	July 1980	NBL-296	U
Safeguards Analytical Laboratory Evaluation (SALE)	July 1980	unnumbered	U
An Investigation of the Properties of UO_3 in a Fluidized-Bed Denitration Unit	June 1980	ENICO-1041	U
Safeguards Analytical Laboratory Evaluation (SALE)	May 1980	unnumbered	U
Study of the Potential Uses of the Barnwell Nuclear Fuel Plant (BNFP)	March 1980	IEAL-141A	U
Safeguards Analytical Laboratory Evaluation (SALE)	March 1980	unnumbered	U
Safeguards Analytical Laboratory Evaluation (SALE)	January 1980	unnumbered	U
An Evaluation of an Automatic Uranium Titration System	January 1980	NBL-294	U

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